# Clark County's NPDES Phase I Stormwater Management Effectiveness Monitoring: Targeted Environmental Outcomes

# Final Report


Prepared by

Bob Hutton, Natural Resource Specialist III
Clark County Department of Environmental Services
Clean Water Program


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# Summary and Conclusions

## Purpose

This report addresses the final reporting requirements under section S8.E of Clark County's 2007 Phase 1 Municipal Stormwater Permit to monitor and evaluate the effectiveness of a county stormwater management program (SWMP) action in achieving the targeted **environmental outcome** of reducing fertilizer nutrients and pesticides in residential stormwater. A related S8.E evaluation of just the effectiveness of the SWMP action, a fertilizer and pesticide education campaign for residents in a focused study area, is presented in a separate report. The goal of the targeted action was to help control a typical stormwater problem by changing residents' knowledge and behavior in the use of fertilizers and pesticides detected in stormwater that's also reflected in an environmental outcome of stormwater quality changes. This report evaluates the effectiveness of this outcome by testing the hypotheses of significant reductions, between pre- and post-education periods, in monitored stormwater's median fertilizer nutrient and pesticide levels at the downstream portion of the study area's stormwater collection system.

## Study Area, Monitoring Approach, and Data Analyses

The study area is located in the Felida neighborhood of southwestern unincorporated Clark County. The monitored high density residential (HDR) site's 240 acre upstream drainage area land uses consist of approximately 82% single family residential, 17% multi-family residential, and 1% parks. The HDR stormwater exits the conveyance system approximately 1500 feet downstream of the study's monitoring station through a 36 inch pipe at an outfall near Lake River's confluence with Vancouver Lake.

This S8.E study utilized water quality, flow, and precipitation monitoring results obtained using standardized procedures under Clark County's aligned S8.D permit-required stormwater characterization monitoring project at the HDR site. Details of the monitoring design can be found in that project's Quality Assurance Project Plan (QAPP).

From March 2010 through November 2013, continuous flow and precipitation measurements were made and representative flow-weighted composite stormwater samples were collected during storms that met permit criteria. This required remotely setting storm-specific pacing for above-ground accessible automated water samplers so that representative subsamples could be collected using below-ground level stormflow intake lines in the HDR site's stormwater manhole. Additionally, sediment sample collection bottles were deployed for extended periods on the upstream side of a flow control weir located within the manhole. All monitoring data adhered to program QA/QC procedures and was finalized prior to statistical analyses.

Statistical analyses followed the generally accepted procedures of: exploratory graphical analyses, addressing statistical assumptions, and then formal statistical testing. Analyses emphasized time series plots, boxplots and, based on the monitoring datasets characteristics, the use of robust nonparametric Mann-Whitney rank sum statistical tests on medians. Statistical analyses focused on comparisons of pesticide and fertilizer nutrient concentrations or loads from before (pre-outreach) and after (post-outreach) the beginning of the education campaign on April 1, 2012.

## Findings

The following bullets summarize important findings and context for this study:

- Rank-sum statistical tests show that only 2 of the 13 monitored parameters, herbicide dichlobenil and nutrient nitrate-nitrite as N, had statistically significant decreases in their median concentrations from the pre- to post- education periods. However, 75% of dichlobenil's concentrations were less than the lab's reporting limits and below Ecology's MRL upper target range; suggesting all low values.
- Separate from dichlobenil, 5 (55%) of the 9 monitored pesticides each had more than 70% of their respective concentrations as non-detects which did not allow meaningful statistical comparison between their medians. This suggests for these pesticides, both their pre- and post- education concentration values were very low and probably approaching irreducible concentrations.
- Similarly, the National Stormwater Quality Database excludes summary statistics about organics (including pesticides) because they were mostly all not detected in various Phase 1 studies. However, HDR's entire pre- and post- education median nutrient concentrations appeared to be lower than those found nationally.
- The rank-sum test results show statistically significant increases in the medians between pre- and post- education periods for both ortho-phosphorus as P and total phosphorus concentrations. However, graphical boxplot summaries suggest the differences in median concentrations are not substantial for ortho-phosphorus.
- Of all the monitored parameters, the only difference in the median loads that tested as significant was also an increase from pre- to post education period total phosphorus median loads. Again, boxplots suggest the general tendency of this loading difference is not substantial nor of practical significance.
- Pentachlorophenol was the only detected pesticide in sediment to decrease.
- Generally the water quality monitored storm volumes were similar for the pre- and post- education periods and their median values did not appear to be significantly different. The overall similarity in the two periods' storm volumes suggests that differences between them are unlikely to be a substantial driver or confound analyses of differences in median loads.

## Conclusions

Overall, this study showed that monitored nutrients and especially pesticide concentrations were relatively low, with most pesticides results below the laboratory's most sensitive detection limits. Statistical testing required focusing on results after 2010 that had more than 30% detected values. In addition to using robust nonparametric statistics, graphical exploratory analyses provided insights into the practicality of statistically significant differences between pre- and post- education period results.

The study area's education campaign may have helped protect water quality. While a statistically significant reduction was found in the herbicide dichlobenil, it's not possible to link it to the education campaign due to other potential causes and the study's limited scope. Also, significant reductions found in nitrate-nitrite and increases in total phosphorus concentrations or loads are not of practical significance and may be due to a range of causes unrelated to the education campaign. Frequent nondetected pesticide results limit feasibility of statistical analysis of effectiveness for this and future projects.

# Introduction

Pollutants carried by stormwater runoff remain one of the main sources of water pollution nationally. In implementing section 402 of the 1987 reauthorized Clean Water Act, the U.S. Environmental Protection Agency (EPA) requires larger urban areas and industries to report progress on stormwater runoff under the National Pollutant Discharge Elimination System (NPDES) permit (EPA, 2002, Urban Stormwater BMP Performance Monitoring, p. 4). Residential activities can result in nutrients such as nitrogen and phosphorus from fertilizing landscapes and herbicides or insect ides for pest control contributing to stormwater pollution (Minton, 2002, pp. 14-17).

The purpose of this report is to evaluate achievement of targeted environmental outcomes and address final reporting requirements for Clark County under the 2007 NPDES stormwater permit Section S8.E Stormwater Management Program Effectiveness Monitoring. The targeted outcomes are evaluated by comparing a study area's monitored stormwater water and sediment quality before and after the beginning of a front loaded stormwater pollution prevention education campaign that ran from April to December 2012. Monitoring occurred for over 35 months and extended for one year after the end of the campaign to help capture potential impacts and improve representativeness. The campaign's education focused on informing its residents about the proper use of and potential pollutant impacts from fertilizers and pesticides detected in stormwater from the study area. The education campaign and a related evaluation of this action's effectiveness, based on before and after surveys of the study area residents versus a control area's residents, are summarized in a separate related S8.E evaluation report.

This report is organized into the major remaining sections of methods, results and discussion, and quality assurance / quality control. The methods section briefly describes the overall study vicinity, drainage area and land uses, monitoring design and methods, and general data analysis approach. The results and discussion section presents exploratory data analyses and test statistics results of monitoring values along with their interpretation. The next section, the quality assurance / quality control section, includes an evaluation of the project's data based on the project's measurement quality objectives and the overall usability of the monitoring results. The last section provides conclusions.

This report's targeted effectiveness monitoring of outcomes is part of a larger NPDES stormwater permit required monitoring effort undertaken by Clark County at stormwater characterization sites, a flow-reduction Best Management Practice (BMP) site, and stormwater treatment BMP monitoring locations (Figure 1). This report addresses the evaluation of stormwater outcomes for the study area draining to the high density residential (HDR) site's monitoring station labeled as "Characterization: High Density Residential" in Figure 1.

All water and sediment quality monitoring data will be submitted with this report in digital and hardcopy form, as part of a verified and validated data package. Summaries of Clark County's other monitoring results for stormwater characterization and stormwater Best Management Practices effectiveness have been addressed previously in separate final reports submitted to the state.

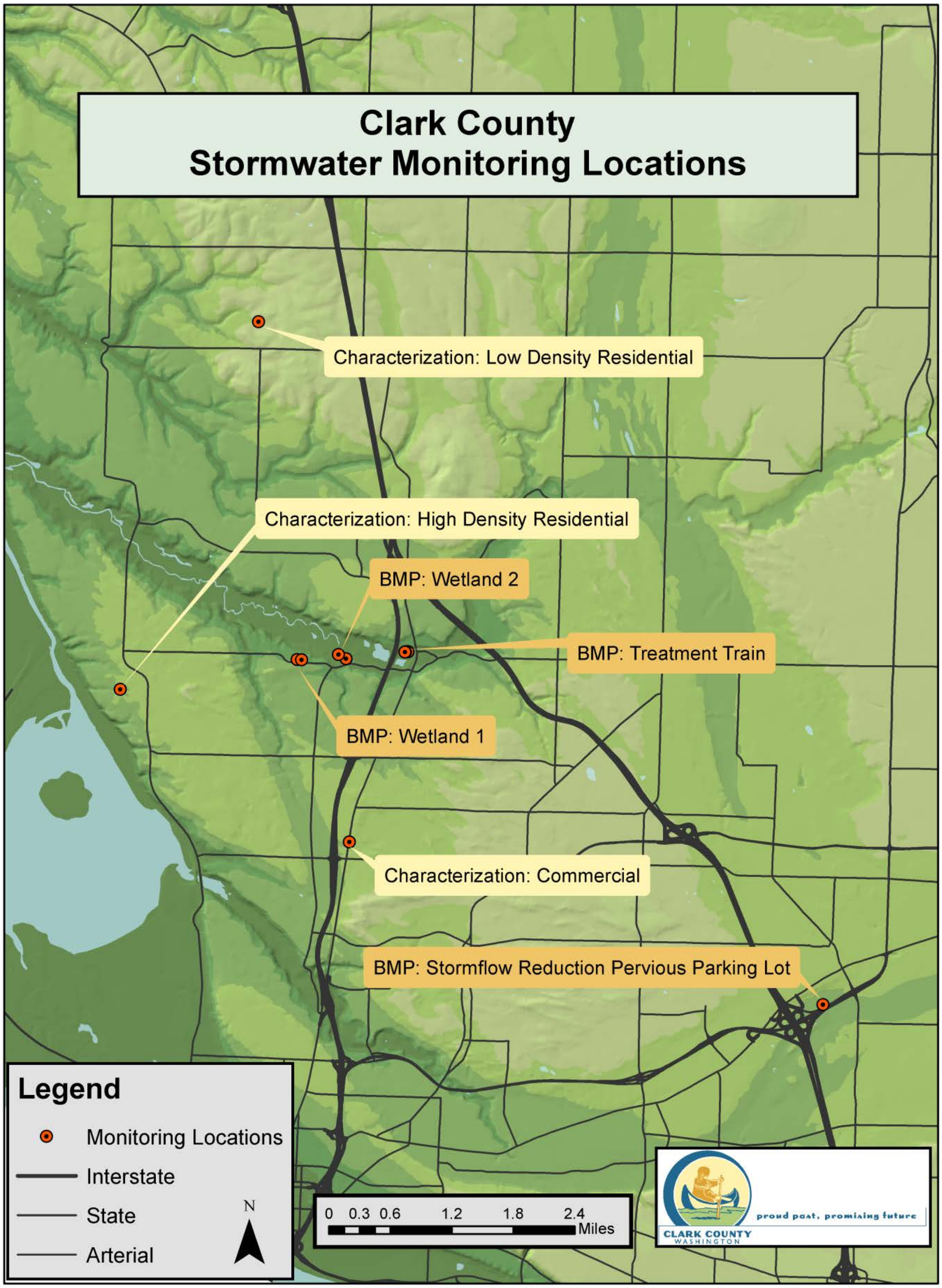


**Figure 1 Stormwater monitoring locations within southwestern Clark County**

# Methods

## Study Area Location, Land Uses, and Drainage

The HDR study area is located in the unincorporated Felida neighborhood of southwestern Clark County about 3 miles southwest of the intersection of I-5 and I-205. The 240 acre area extends approximately between NW 119$^{th}$ and 105$^{th}$ Streets from north to south as well as between NW 36$^{th}$ and 21$^{st}$ Avenues from west to east (Figure 2).

The HDR site's upstream drainage area, much of which was developed in the last 20 years, is characterized by mostly medium to high density residential land uses with average lot size of under ¼ acre. Its land uses consist of approximately 82% single family residential, 17% multi-family residential, and 1% parks. It drains through a stormwater conveyance system to the dual purpose HDR monitoring site used for this S8.E project as well as for the S8.D Stormwater Characterization Monitoring. Stormwater exits the system approximately 1500 feet downstream of the study's monitoring station through a 36 inch pipe at an outfall near Lake River's confluence with Vancouver Lake.

The area is within the northern-most portion of the Willamette Valley Ecoregion (Clark County, 2011, QAPP SWMP Effectiveness Monitoring, p. 9). Generally, the study area is comprised of gently rolling hills cut by small streams that drain west to Lake River.

## Overall Monitoring Approach Summary

Water quality, hydrology, and sediment monitoring were performed in accordance with Clark County's section S8.D requirements under the 2007 NPDES stormwater permit and the S8.D Quality Assurance Project Plan (QAPP) for Stormwater Characterization Monitoring (Clark County, 2011). This QAPP includes more detailed monitoring design information and guided the monitoring for both this S8.E outcome monitoring and the concurrent S8.D monitoring that allowed dual use of the HDR monitoring site's data. Standard Operating Procedures (SOPs) are also summarized in the QAPP's appendices.

The following summarizes typical storm water quality monitoring at the HDR site. A commercial weather forecasting service was reviewed daily for qualifying forecasted storms (at least 0.2 inches of precipitation with either 24 or 72 hours of antecedent dry period for the wet and dry seasons, respectively). As a qualifying storm approached, staff went to the HDR monitoring station and performed pre-storm set-up (Figure 3). Later, field staff would remotely set (via cell phone telemetry) the final storm-specific sampler pacing based on the latest predicted storm characteristics. After precipitation started and stormflow reached a minimum stage, the programmed autosampler would commence sampling at the designated pacing volume from the upstream side of the control weir (Figure 4). The autosampler continued sampling throughout the storm and pumped the aliquots into, if needed up to four, large composite glass carboys contained in a custom-built, plywood, insulated box to ensure adequate storm sampling coverage and storage. After the storm ended, staff retrieved the carboy(s) of composite samples, labeled the carboys, documented information on lab chain-of-custody and field sheets, and coordinated with laboratory courier service for timely sample pick-up and delivery.

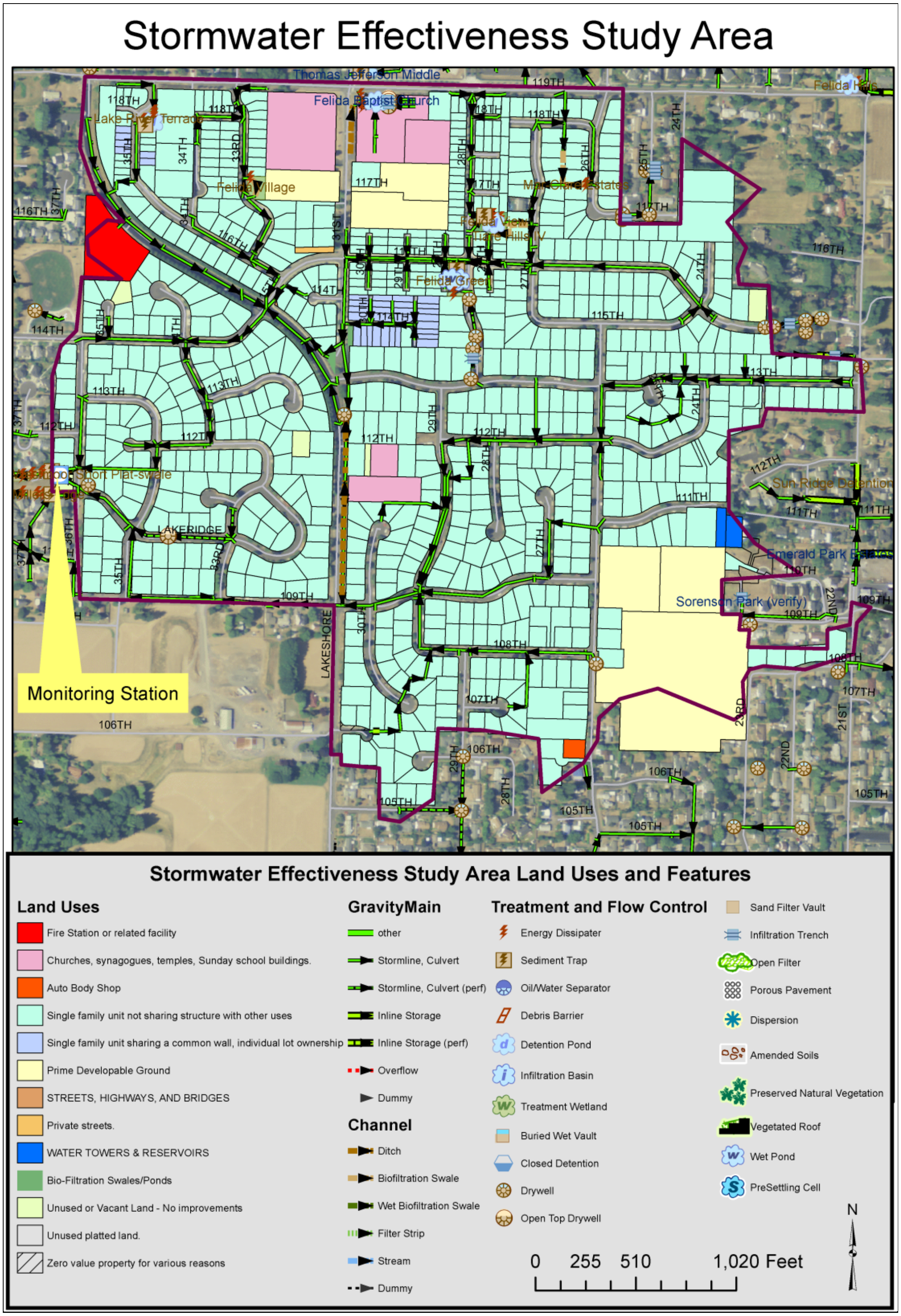


**Figure 2 Stormwater effectiveness study area land uses and features**


**Figure 3 High density residential (HDR) site secure monitoring station equipment box and rain gage**

**Figure 4 View down HDR's stormwater manhole with large v-notch weir on right side**

Lab analyses were performed at the nearby, Ecology-accredited ALS Environmental laboratory located in Kelso, Washington to maximize meeting sample holding times. Lab reported sample concentrations are from the flow-weighted composite samples (Event Mean Concentrations or EMCs) that represent the overall water quality during a monitored storm. All laboratory narrative reports and electronic data results were reviewed by staff for errors and reasonableness with issues addressed by the lab contact.

Additionally, staff maintained the HDR's site's hydrology monitoring equipment on a regular basis. This included routine checking and maintenance of the rain gage and pressure transducer's offsets. Continuous precipitation and flow monitoring and targeted automated sampling occurred from March 2010 through November 2013.

Sediment samples, representing the previous year's accumulated sediment, were collected from the HDR site's in-line sediment trap. The trap utilized a 1-liter bottle (wide-mouthed, amber-glass bottle) installed in a submerged, up-right position on the upstream side of the control weir (Figure 4). These time-composited sediment samples were retrieved on May 16, 2012 for the pre-education period and May 20, 2013 for the post-education period.

Finally, field staff maintained equipment enclosures, autosamplers, data loggers, and telemetry equipment to ensure proper sampler functioning as well as adequate data capture and communication. Large, lockable steel tool boxes (Naack brand) were adapted to protect equipment from the weather and vandalism (Figure 3). ISCO samplers were regularly checked for proper sample volume calibration and if maintenance was needed such as replacement of the sampler intake line or desiccant. Desiccants were also replaced as needed inside the secondary sealed boxes that kept sensitive data logger and modem electronics protected from excessive humidity. A Campbell Scientific data logger wired directly to the ISCO autosampler was maintained to store data, house auto sampler programs, and connect to telemetry equipment. A cellular telephone modem (Sierra Wireless AirLink Raven XT) connected to the data logger and an external antenna was regularly checked to ensure two-way remote communication using LoggerNet software between the monitoring station and office computers or staff smart phones. This provided for automatic daily downloads and data back-ups to a dedicated hydrology data computer and Aquarius time series software to manage the hydrology data. Significantly, the cellular telemetry allowed staff at any time to check equipment status and set autosampler pacing remotely from anywhere with cellular phone communication.

## Overall Data Analyses Approach

Exploratory data analysis of all the HDR monitoring site's pesticide and nutrient concentrations was performed to better understand their characteristics and possible use limitations. All analyses were based on finalized data with non-detect values substituted with one-half their respective detection limits as per Ecology's draft procedures to address nondetects (Ecology, 2010). For all analyses, monitoring data was split into two groups based on whether the monitoring results were from before (pre-outreach) or after (post-outreach) the beginning of the education campaign on April 1, 2012. Time series plot and boxplot graphical exploratory analyses precede formal statistical tests of normal distributions and nonparametric tests of differences in medians of pre- and post-educational period concentrations and loads.

# Results and Discussion

## Time Series Evaluation and Nondetect Limitations on Data Analyses

Initial exploratory data analyses used time series plots of all HDR concentrations from March 2010 through November 2013 (Figure 5 through Figure 17). The plots showed several monitored pesticides with substantially higher detection levels prior to 2011. Therefore, only data from after 2010 was utilized for any further data analyses (only those values plotted to the right of the vertical grey line in the time series plots). This was done to reduce potential confounding impacts on statistical comparisons of pre- and post-education water quality results due to the less sensitive early laboratory analyses. The elimination of pre-2011 data also made the size of pre- and post- education water quality sample sizes more similar thus giving them more equal weight in comparisons.

Labeling of nondetect (U or UJ) and estimated (J) results in the time series plots also allowed visual evaluation of the frequency and pattern of very low concentration results over time. In contrast, points without qualifier labels in the time series plots depict results above the method reporting limits (> MRL) that have a higher confidence in their reported accuracy than the very low nondetects or estimated results.

Antweiler and Taylor (2008, pp. 3732-3738) evaluated several common statistical treatments for below-detection limit (left-censored) environmental data and their impact on calculating basic summary statistics (i.e., measures of central location such as mean, median, 25$^{th}$ and 75$^{th}$ percentiles; or representative spread such as standard deviation and interquartile range). They found that the nonparametric Kaplan-Meier and two alternative substitution techniques, including assigning one-half the detection limit value to censored data were adequate. However they also found, that "at high degrees of censoring (greater than 70% censored data), no technique provided good estimates of summary statistics."

Burton and Pitt (2002, p. 254) also note if there are many "nondetected (left-censored) data, say between 25 and 75% of the observations, statistical analyses are severely limited." They state "it may not be possible to statistically evaluate the effectiveness of a treatment process completely" and making "it not possible to calculate the significance of the differences in the observed concentrations." Additionally, national compilations of Phase 1 stormwater quality monitoring results have shown that even basic and robust statistical analyses such as calculating medians of organics (for example pesticides) is not feasible when most of their results are non-detects (Pitt, et. al., 2004, p.5).

Therefore, based on HDR's often high percentage of nondetected pesticide results, any further statistical analyses (beyond exploratory analyses) is focused on just parameters with more than 30 % of their pre- or post- education grouped concentration results above their respective detection limits. Exploratory graphics are used to depict distributions and central tendencies along with tables to summarize the frequency of very low concentrations including nondetects. However, it was not justifiable to further statistically evaluate sample distributions for normality or compare the pre- and post- education campaign concentration and loads for the following heavily left-censored pesticides: chlorpyrifos, diazinon, malathion, pentachlorophenol and prometon. Additionally, diazinon and prometon are no longer available to non-commercial users but consumers may still have some left over from earlier sales to them (Brun, September 2012, email).

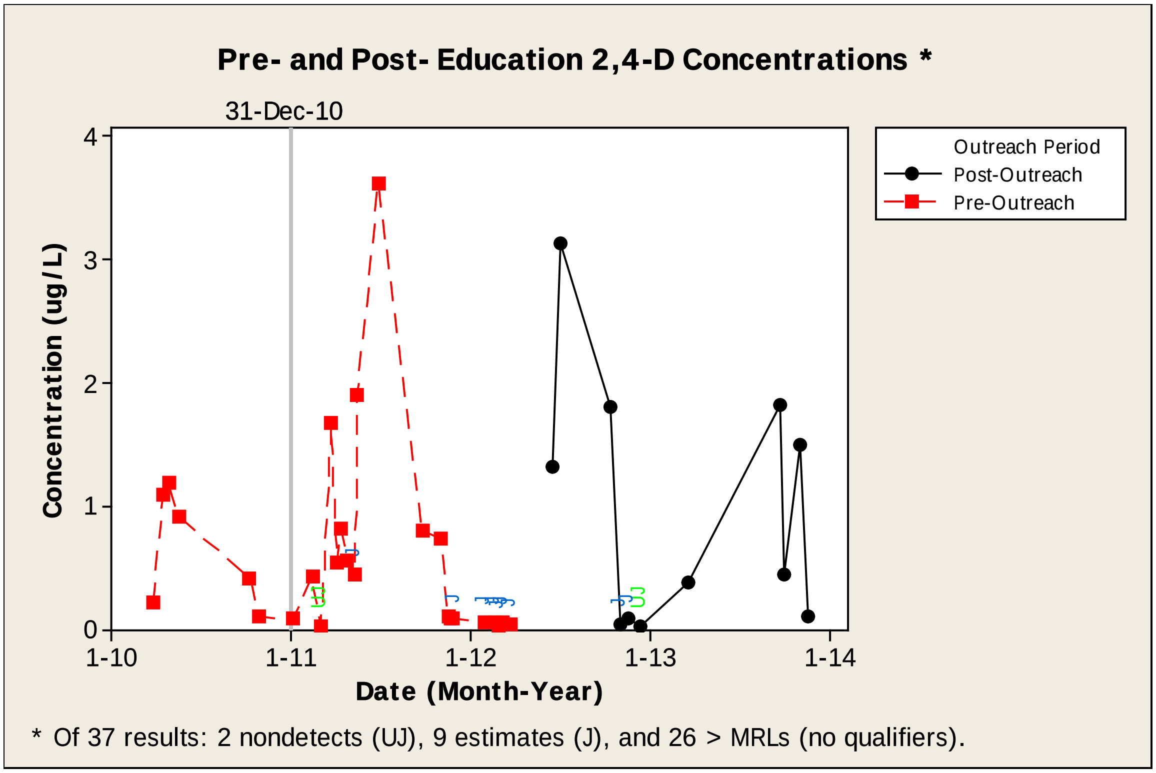


**Figure 5 2,4-D concentrations time series plot**

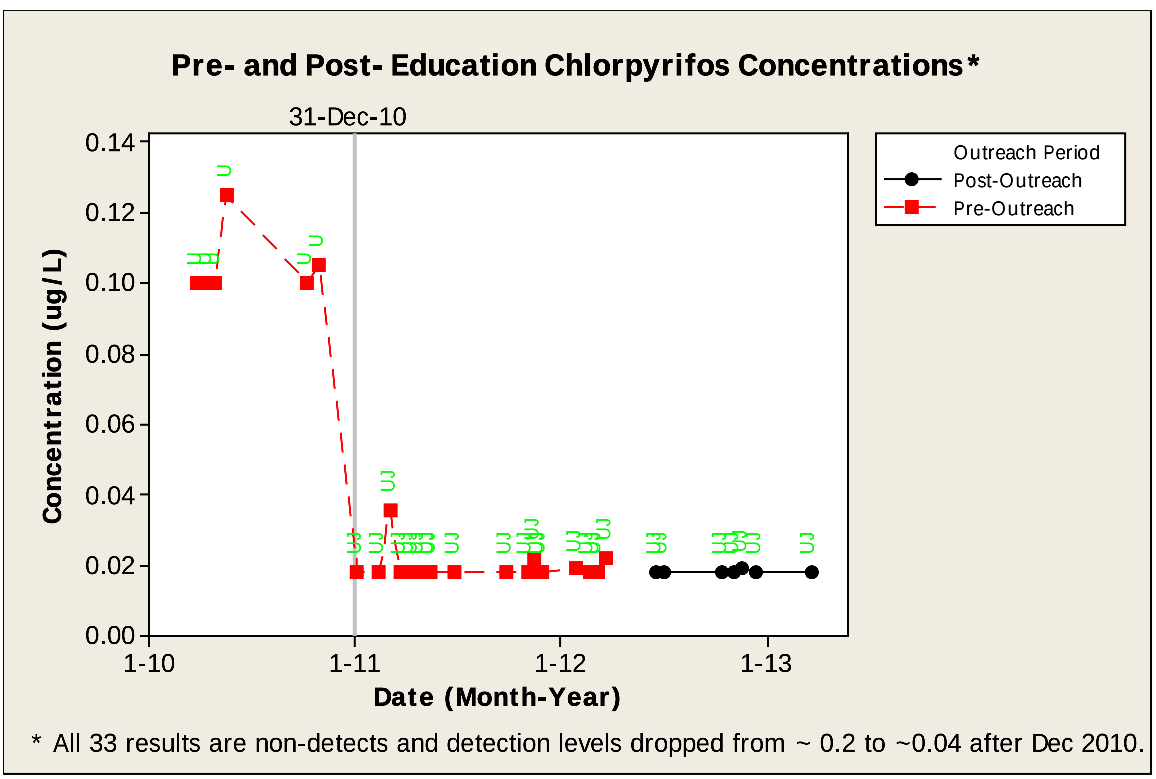


**Figure 6 Chlorpyrifos concentrations time series plot**

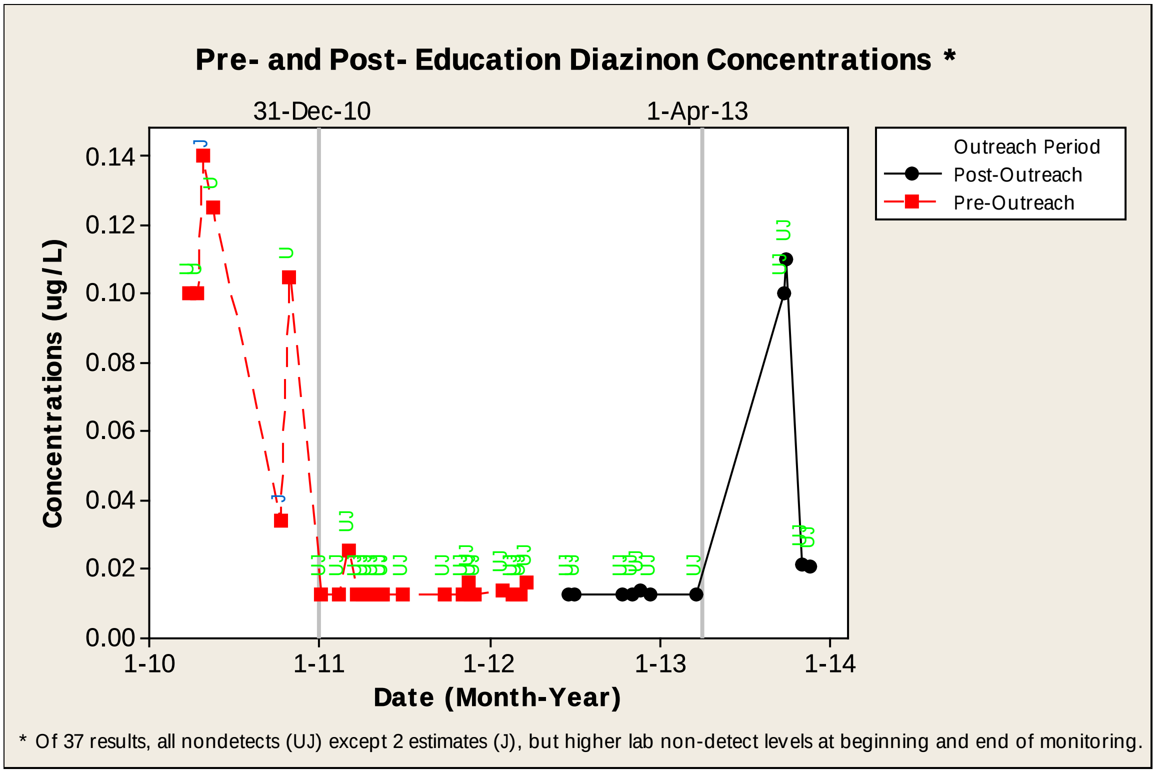


**Figure 7 Diazinon concentrations time series plot**

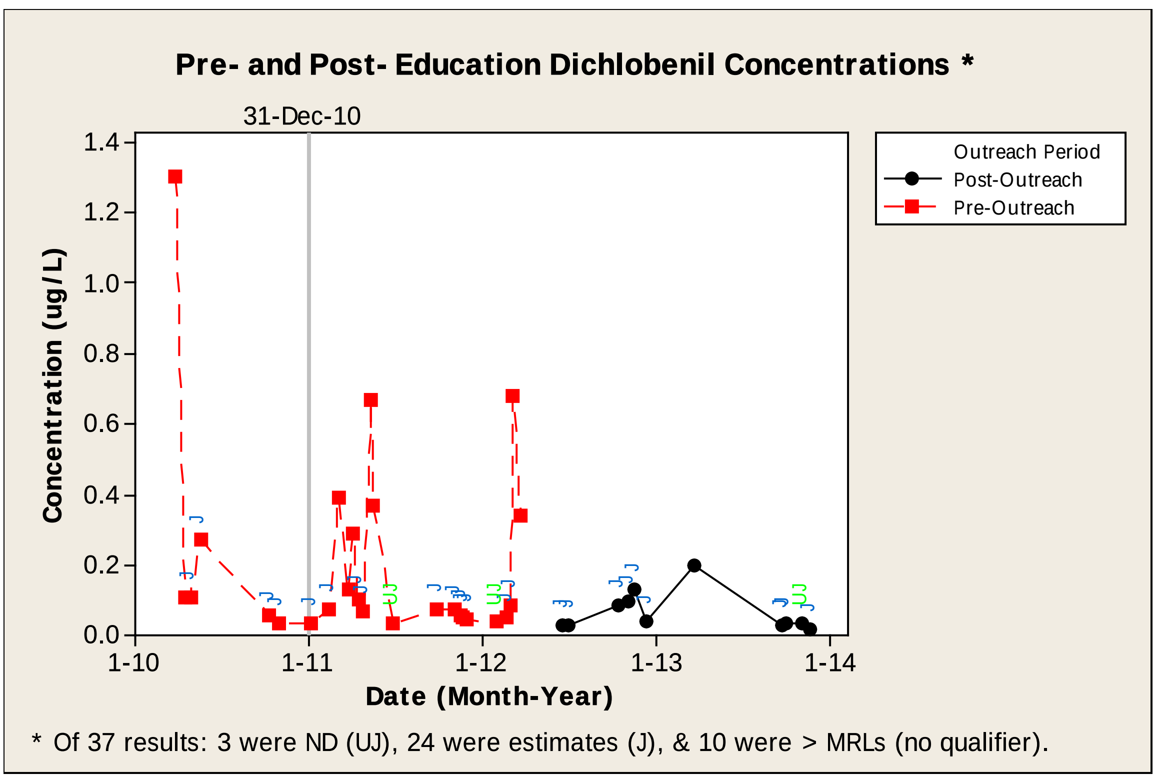


**Figure 8 Dichlobenil concentrations time series plot**

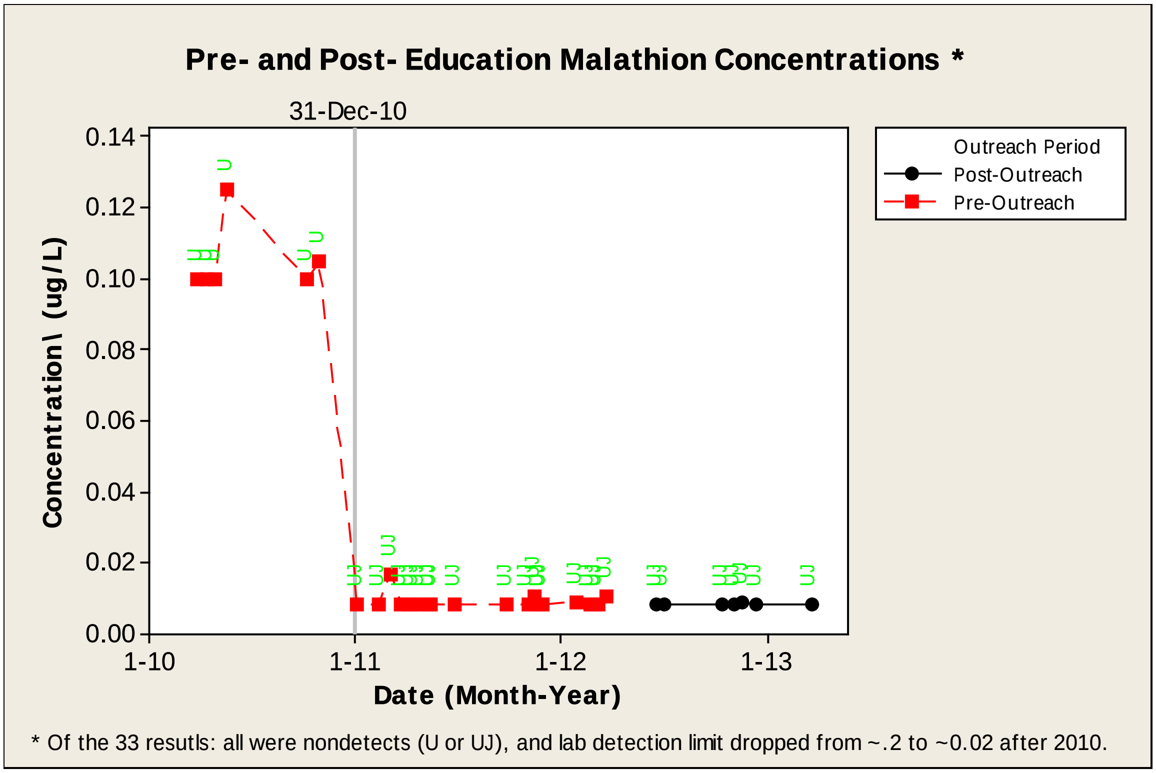


**Figure 9 Malathion concentrations time series plot**

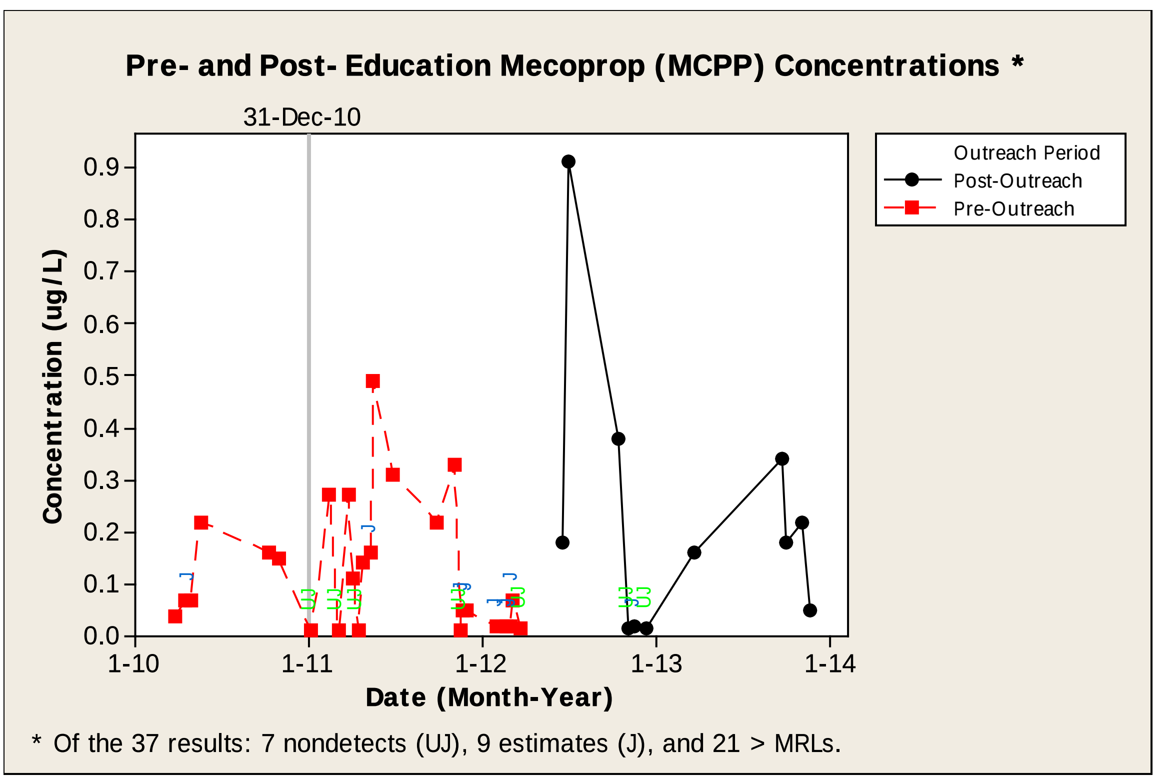


**Figure 10 Mecoprop (MCPP) concentrations time series plot**

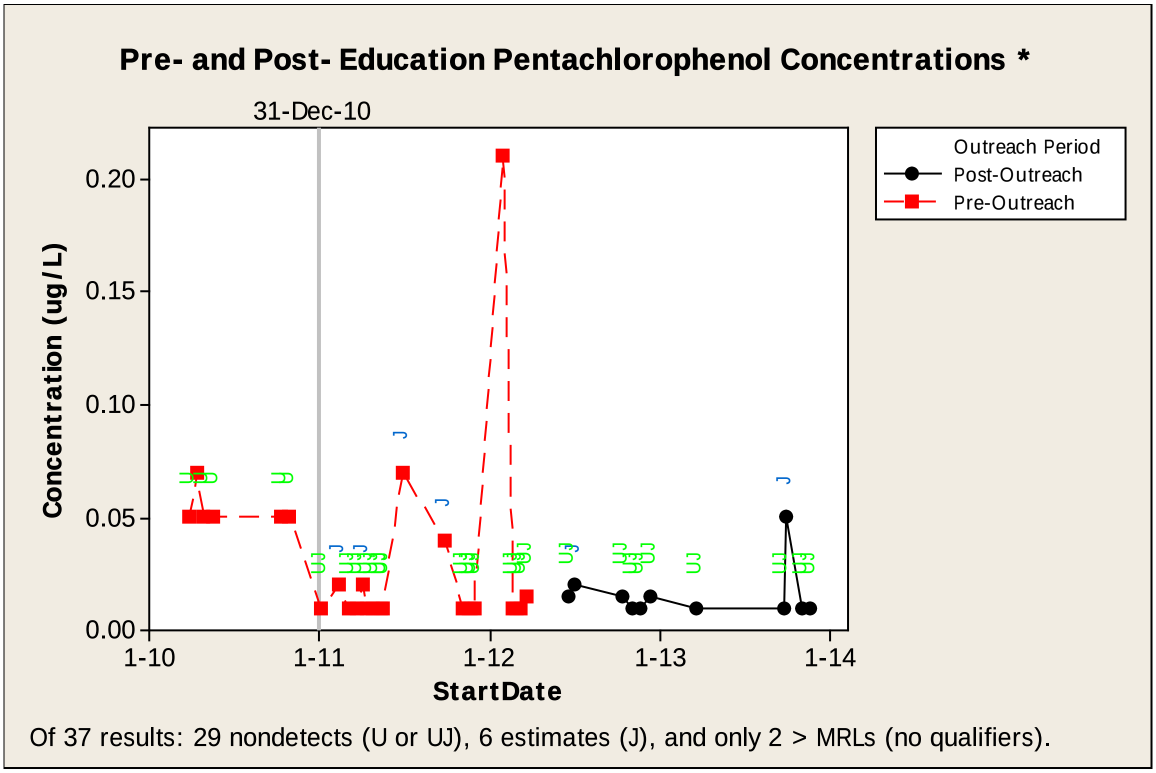


**Figure 11 Pentachlorophenol concentrations time series plot**

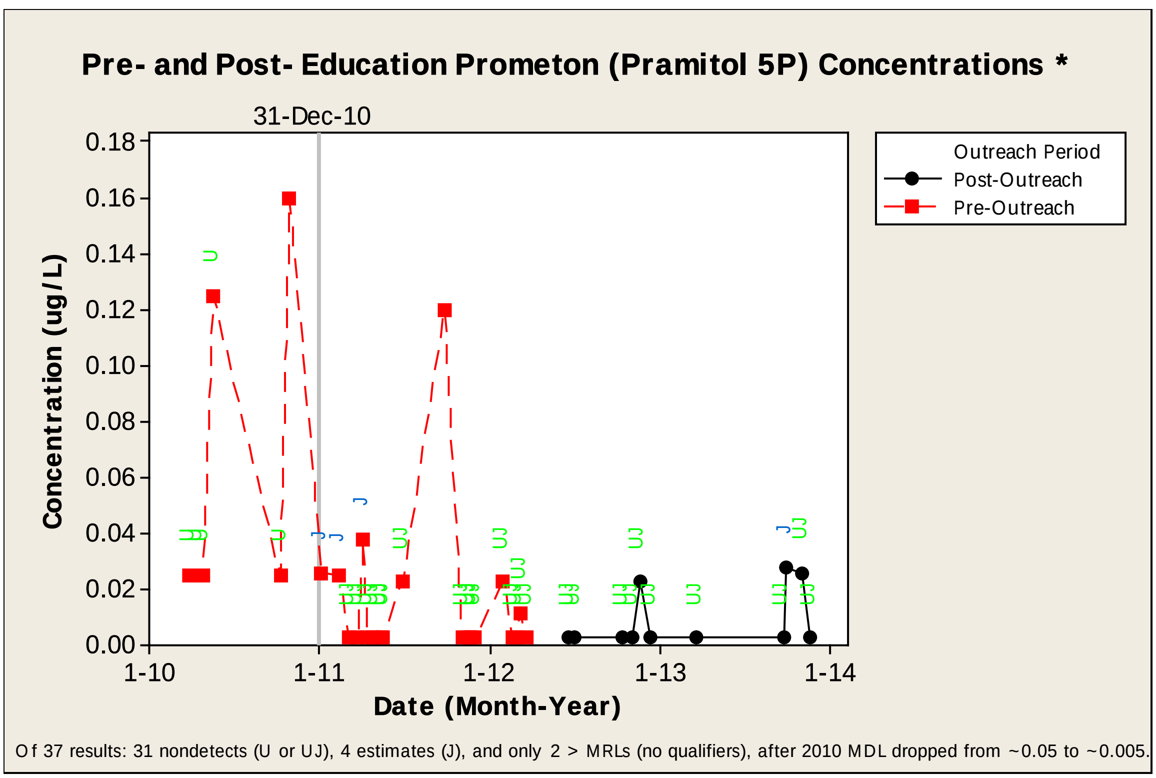


**Figure 12 Prometon (Pramitol 5P) concentrations time series plot**

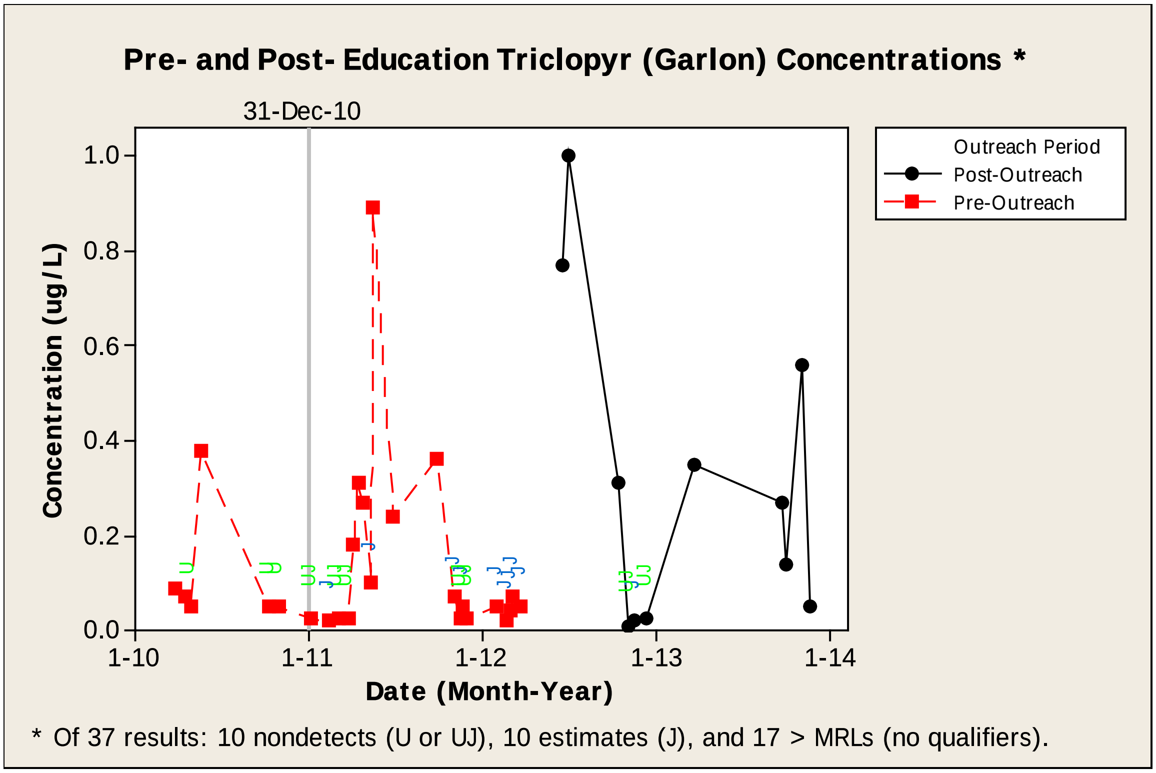


**Figure 13 Triclopyr (Garlon) concentrations time series plot**

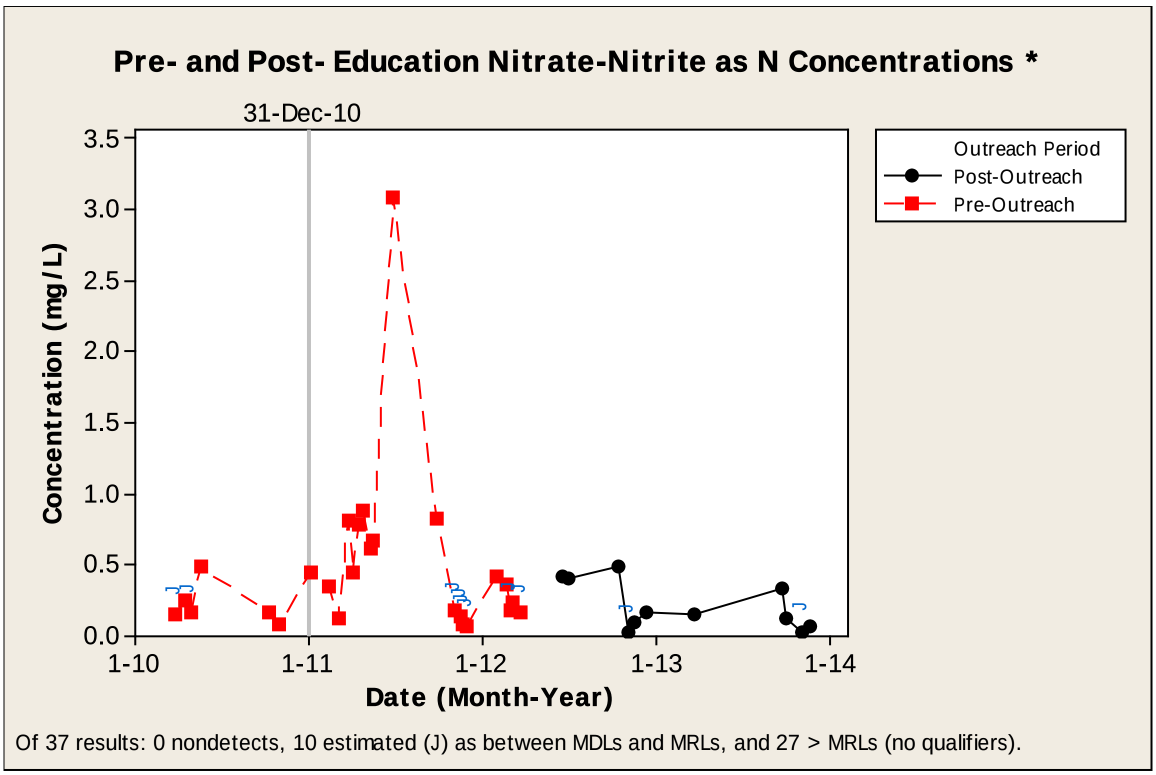


**Figure 14 Nitrate-Nitrite as N concentrations time series plot**

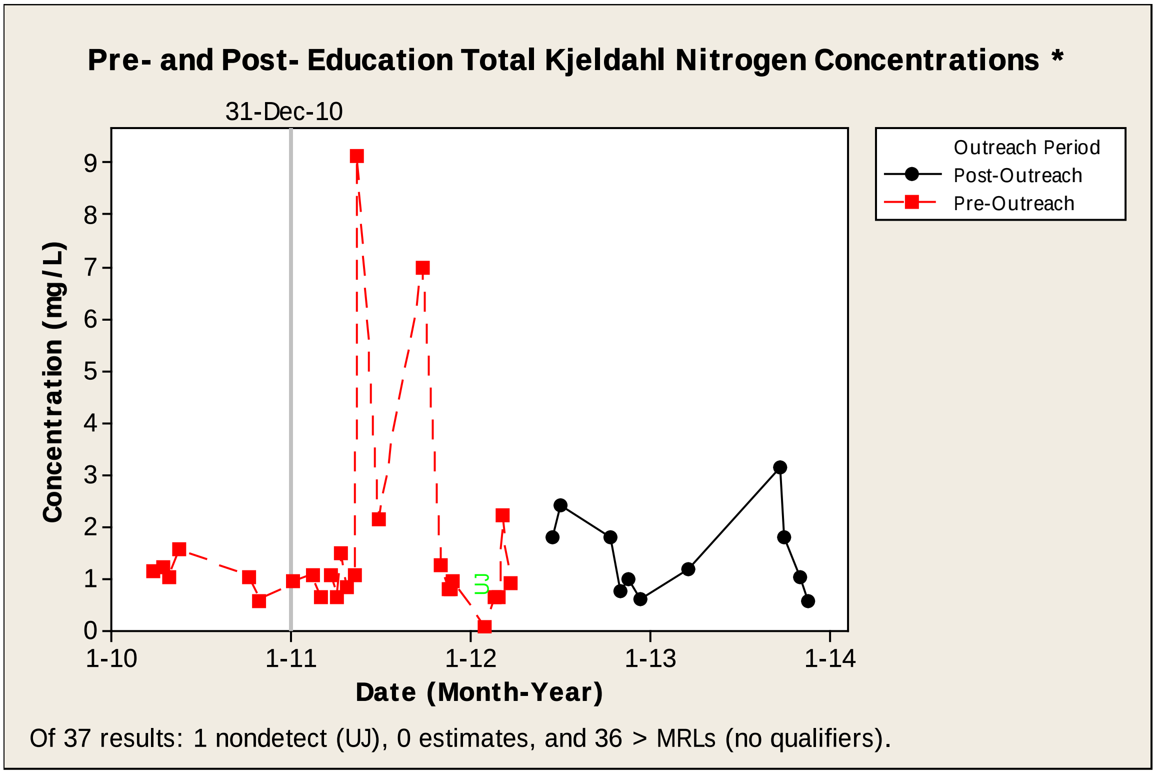


**Figure 15 Total kjeldahl nitrogen concentrations time series plot**

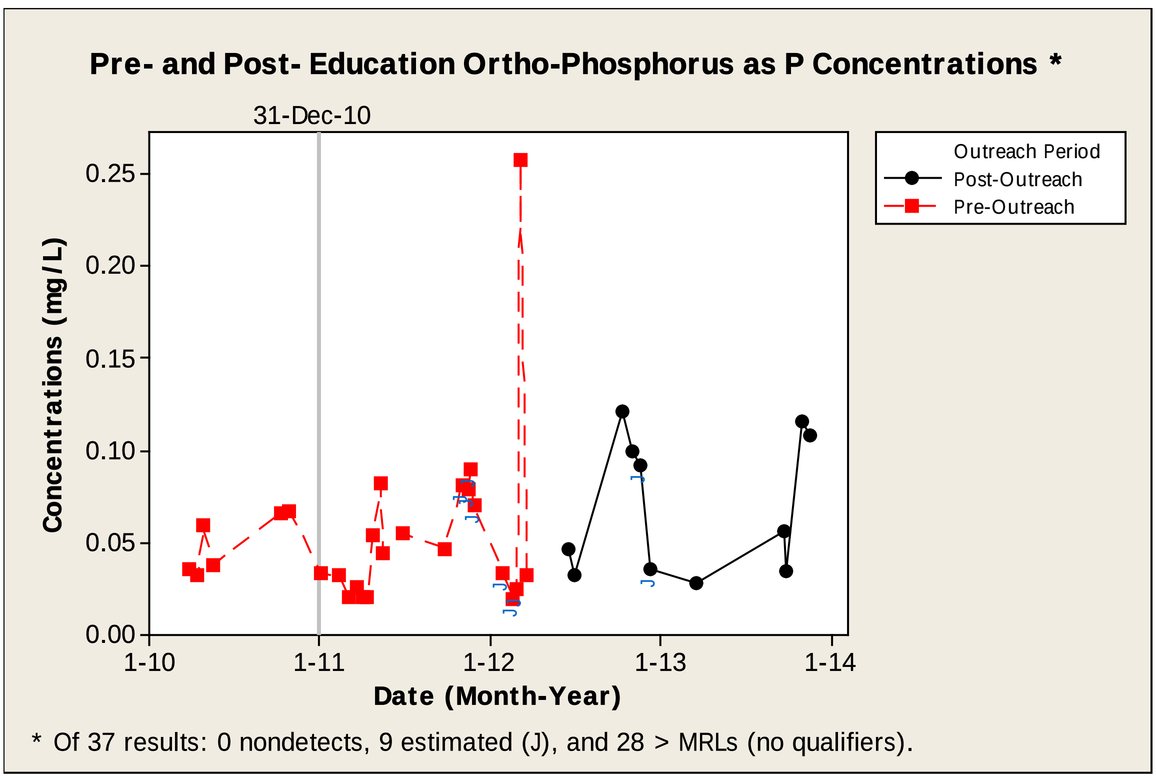


**Figure 16 Ortho-phosphorus as P concentrations time series plot**

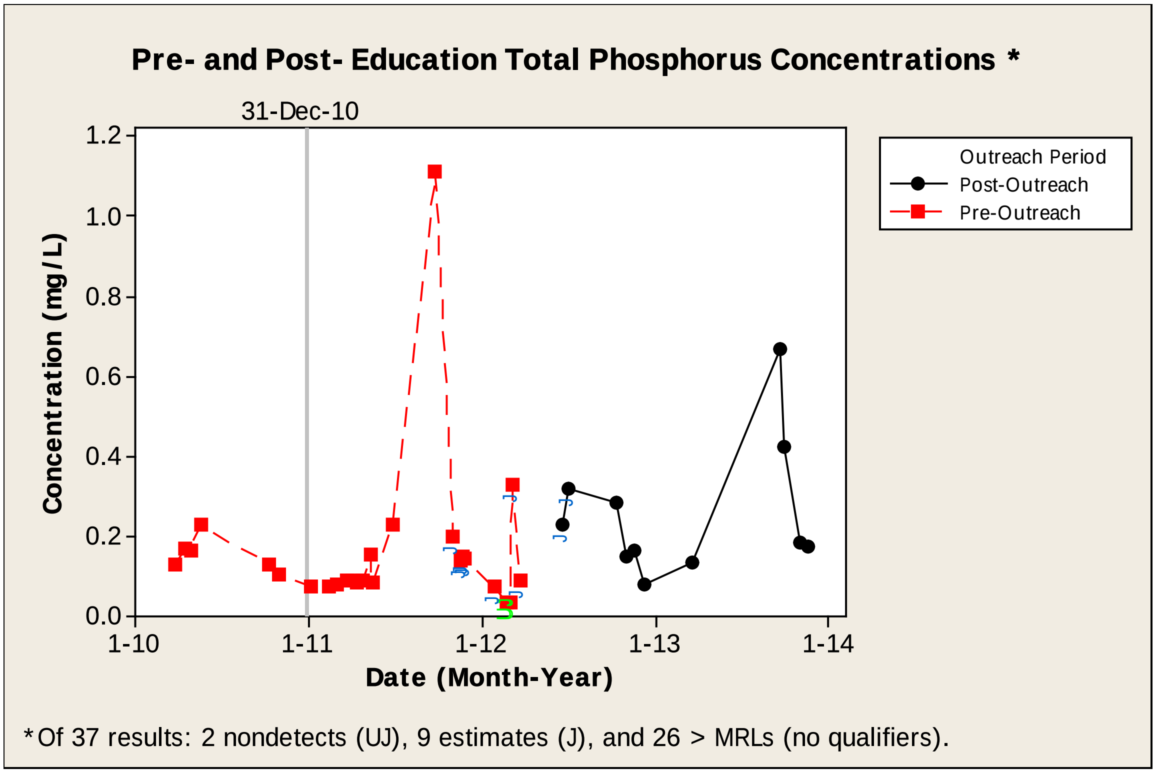


**Figure 17 Total phosphorus concentrations time series plot**

Based on a September 2011 search by Dr. Charles Brun (Washington State University Clark County Extension Service) of the U.S. Department of Health and Human Services Household Products Database, many of the detected pesticides in monitored HDR stormwater are the active ingredients in a wide range of commercial products that are still available to consumers. A list of common commercial pesticide products are provided in the appendices of the S8.E Effectiveness Monitoring Targeted Action Final Report (April 2014) submitted separately from this current report.

## Box Plots Summaries

The distribution and central tendencies of the pre- and post- education periods' monitored concentrations (for all parameters) and calculated loads (for parameters having mostly detected results) are graphically summarized in Figure 18 through Figure 38. The boxplots' depict each monitoring period parameter's data as: medians - green dots that are connected by a green dashed line, 95% confidence interval around the medians - red internal boxes, extreme outlier values – red asterisks, individual values - black hollow dots, $25^{th}$ through $75^{th}$ percentiles or interquartile range – bottom and top of grey shaded boxes, and values above or below 1.5 times the interquartile range – vertical lines extending from shaded boxes.

## Concentration Boxplots

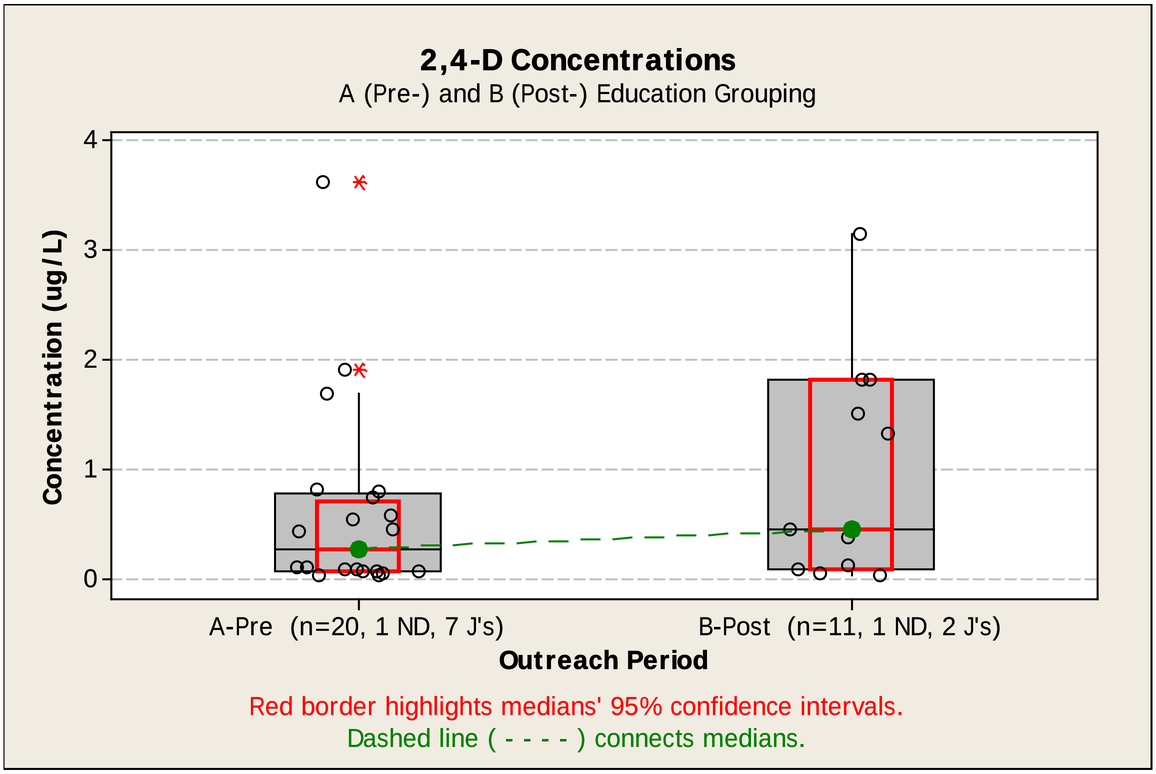


**Figure 18 Storm 2,4-D concentration boxplots**

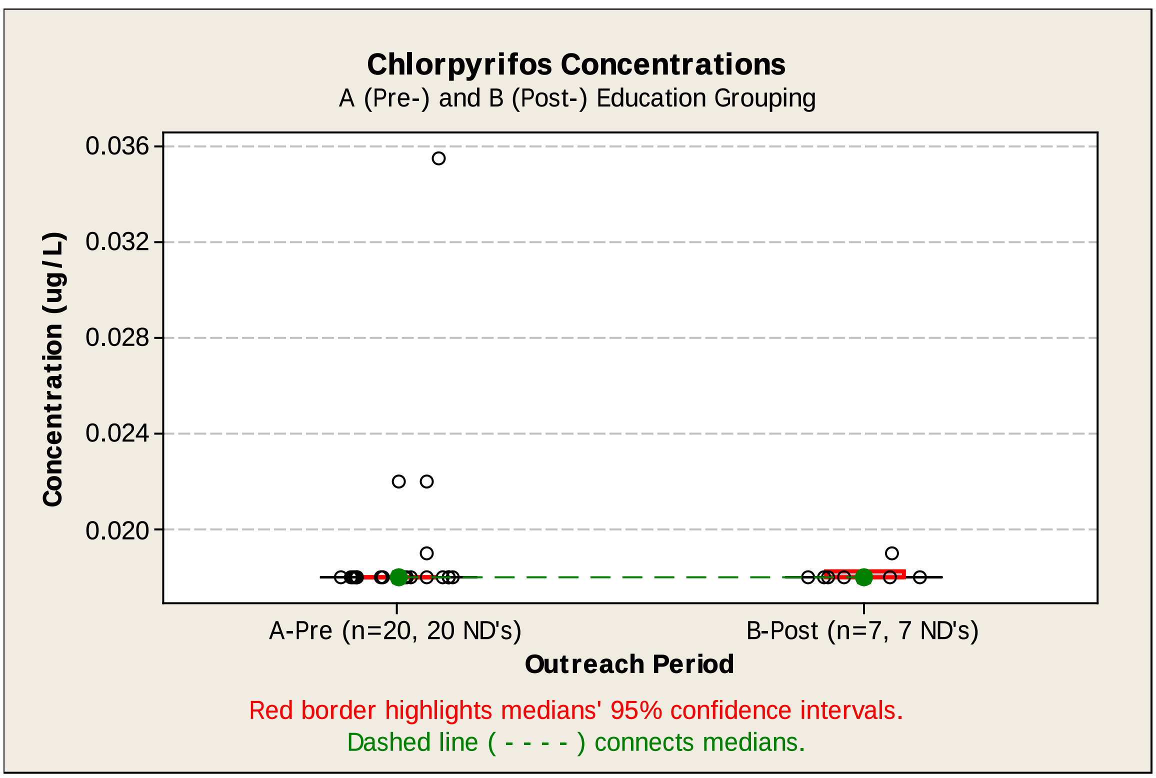


**Figure 19 Storm chlorpyrifos concentration boxplots**

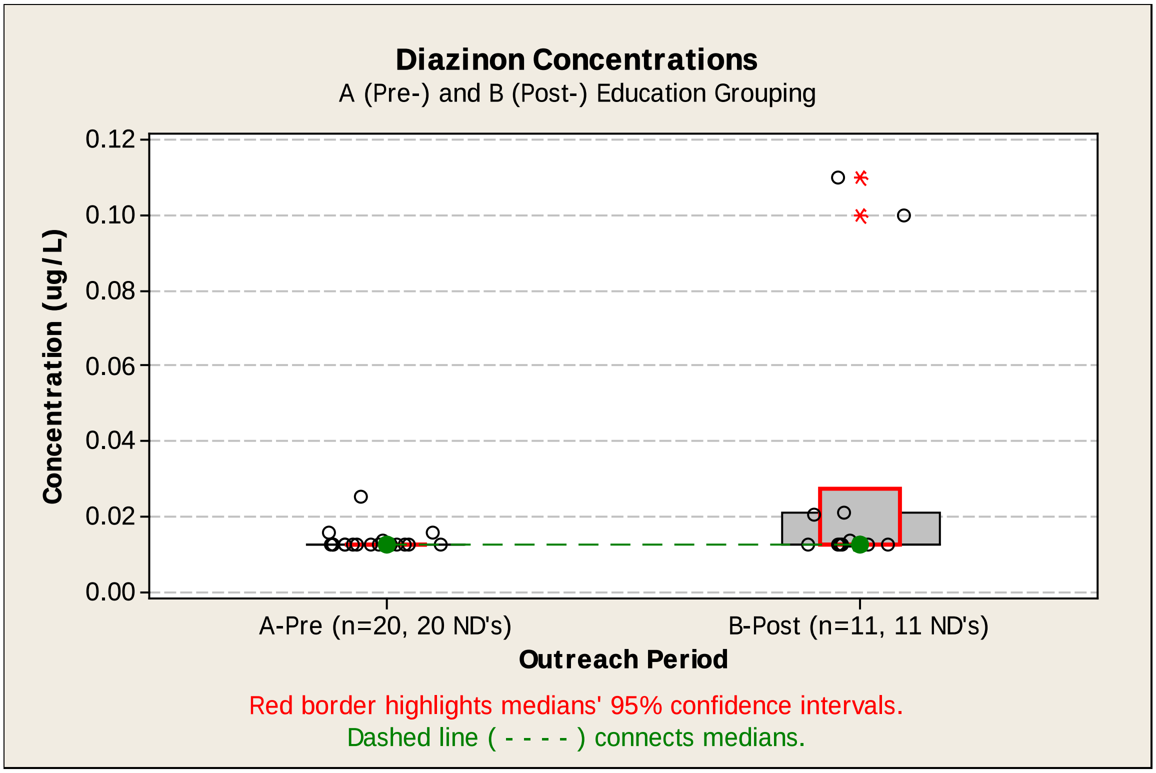


**Figure 20 Storm diazinon concentration boxplots**

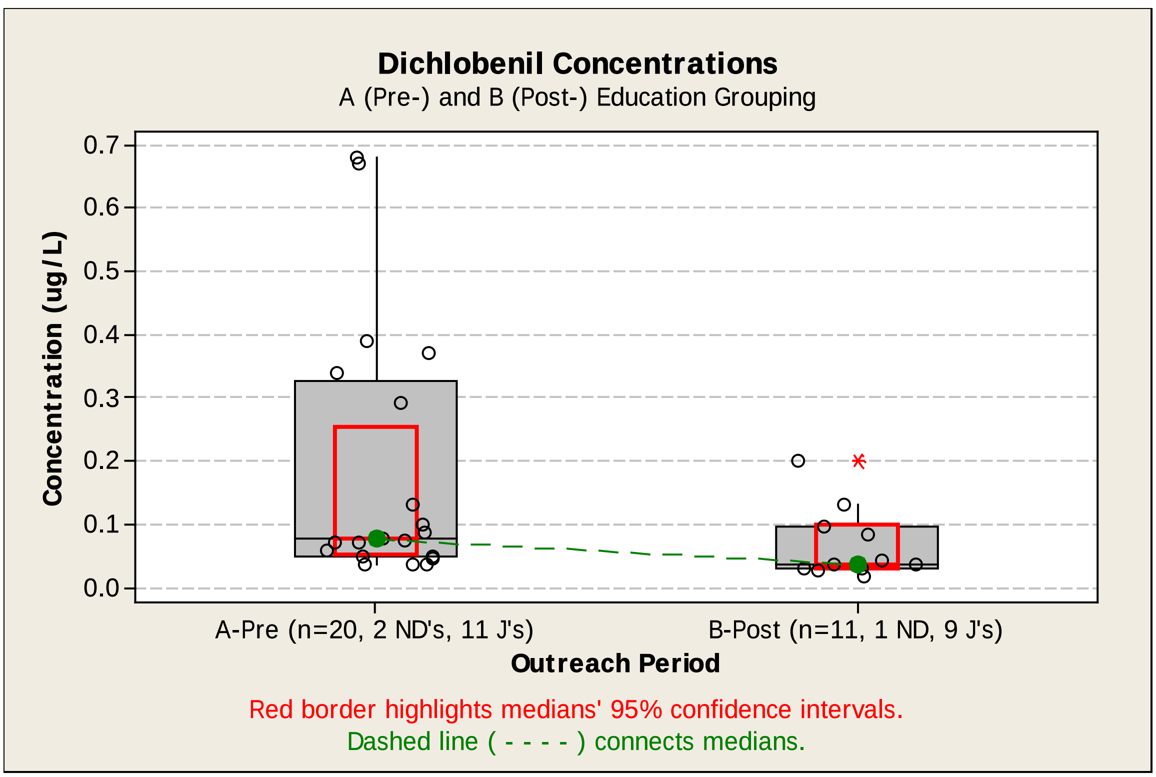


**Figure 21 Storm dichlobenil concentration boxplots**

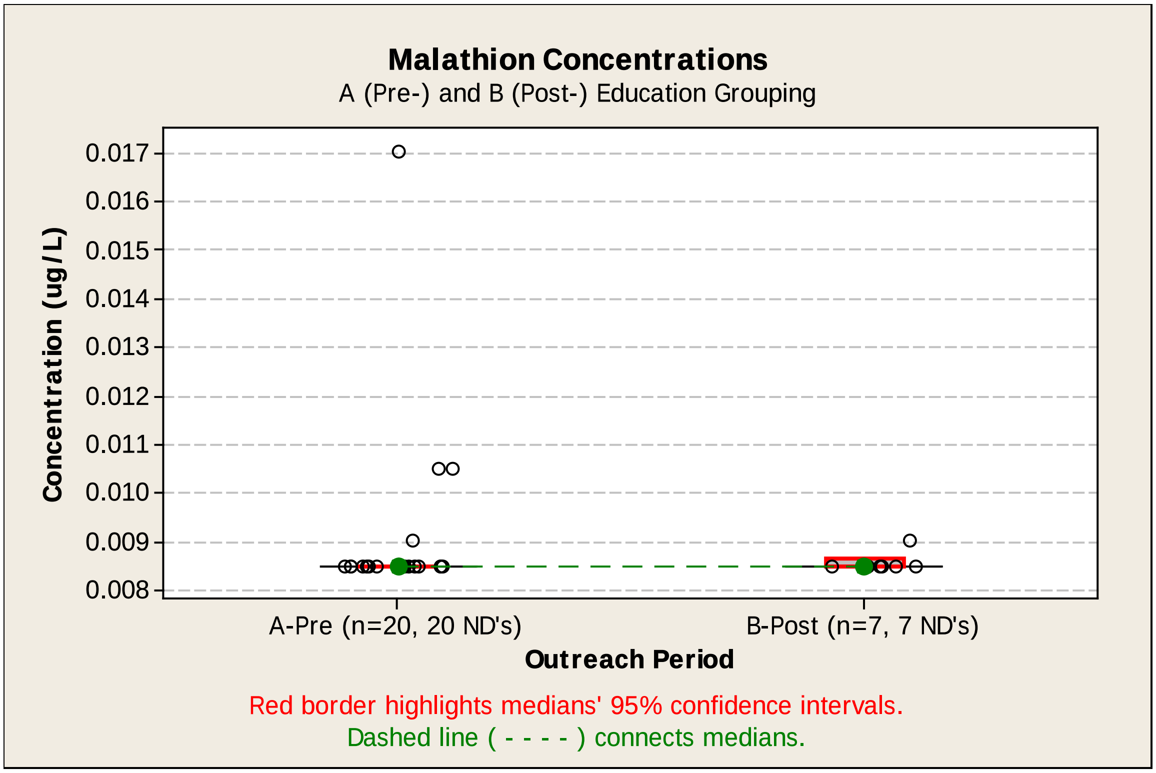


**Figure 22 Storm malathion concentration boxplots**

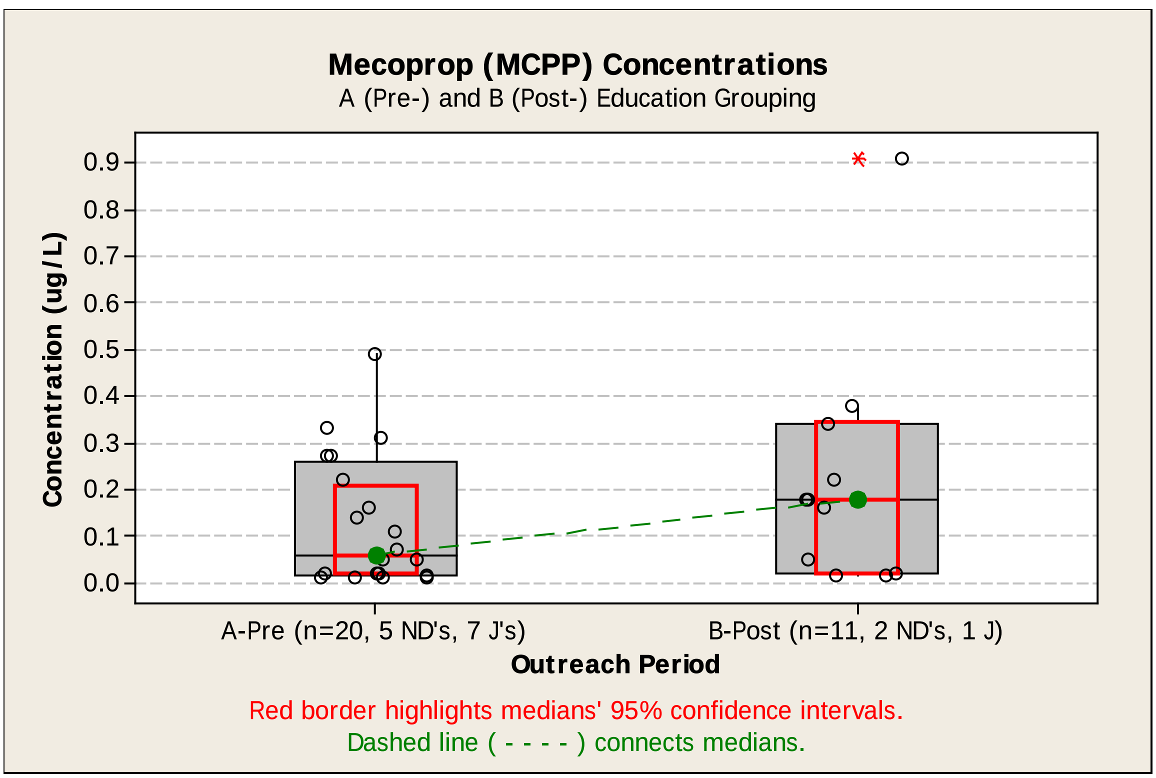


**Figure 23 Storm mecoprop (MCPP) concentration boxplots**

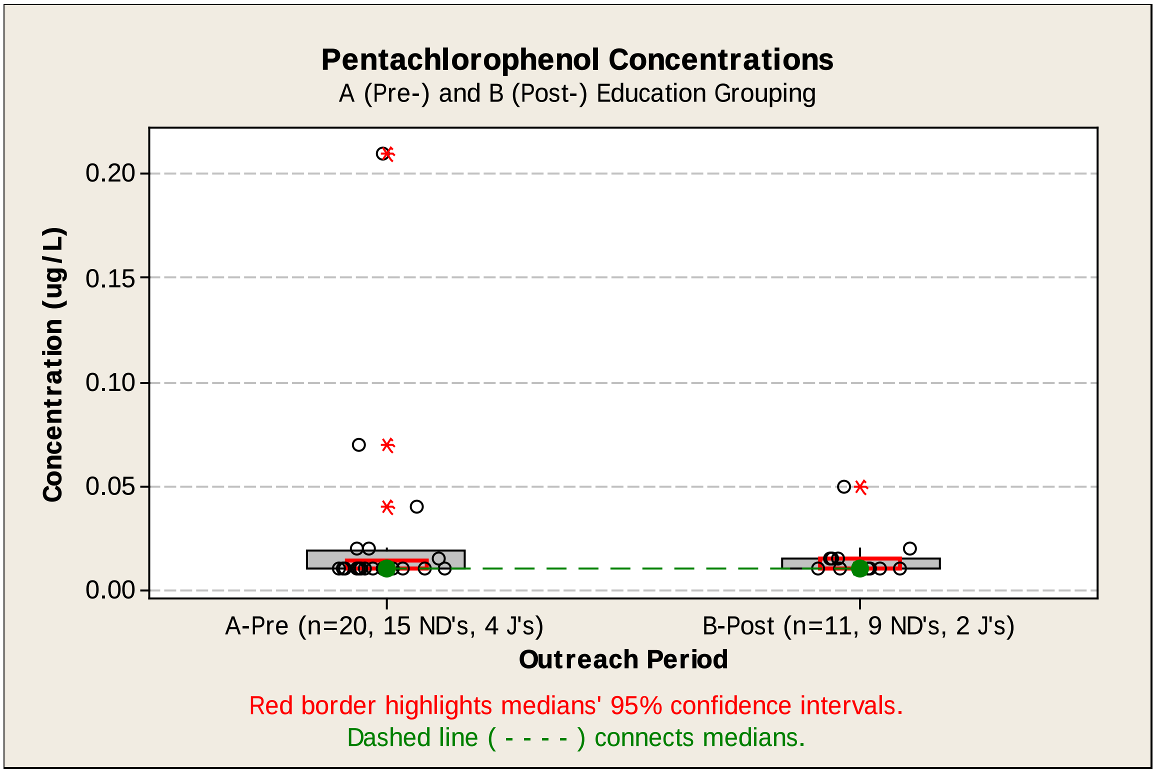


**Figure 24 Storm pentachlorophenol concentration boxplots**

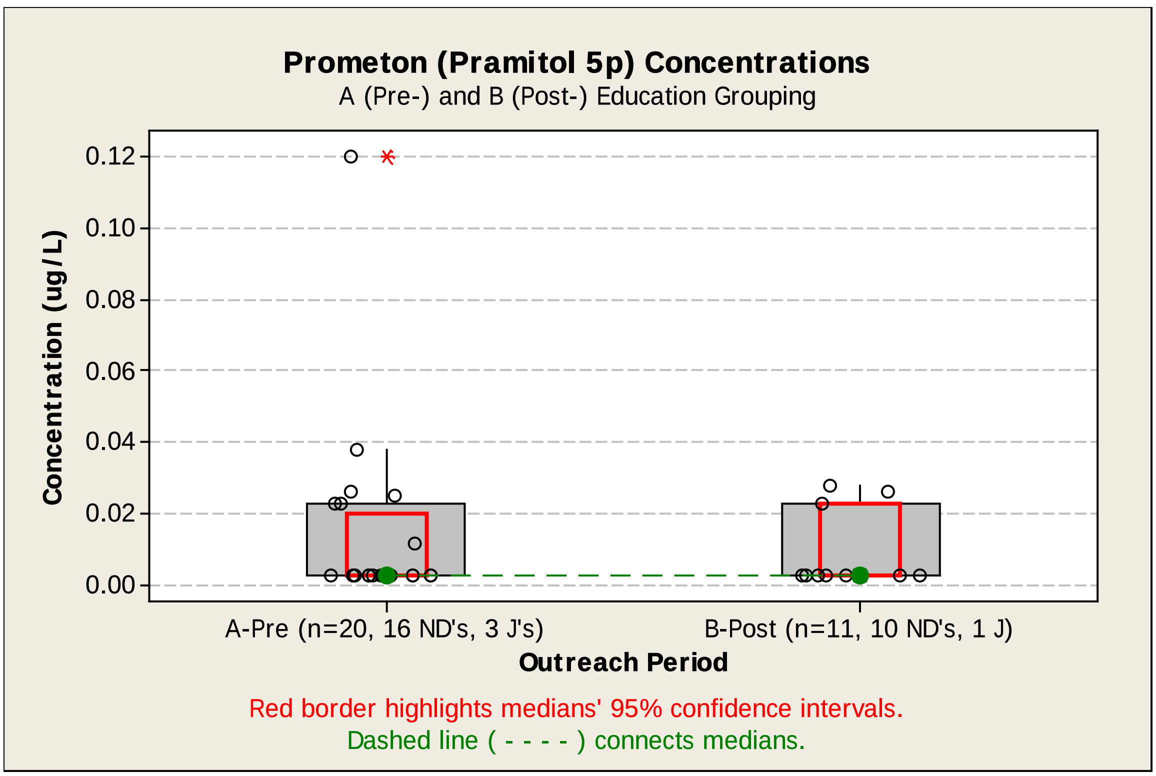


**Figure 25 Storm prometon (Pramitol 5p) concentration boxplots**

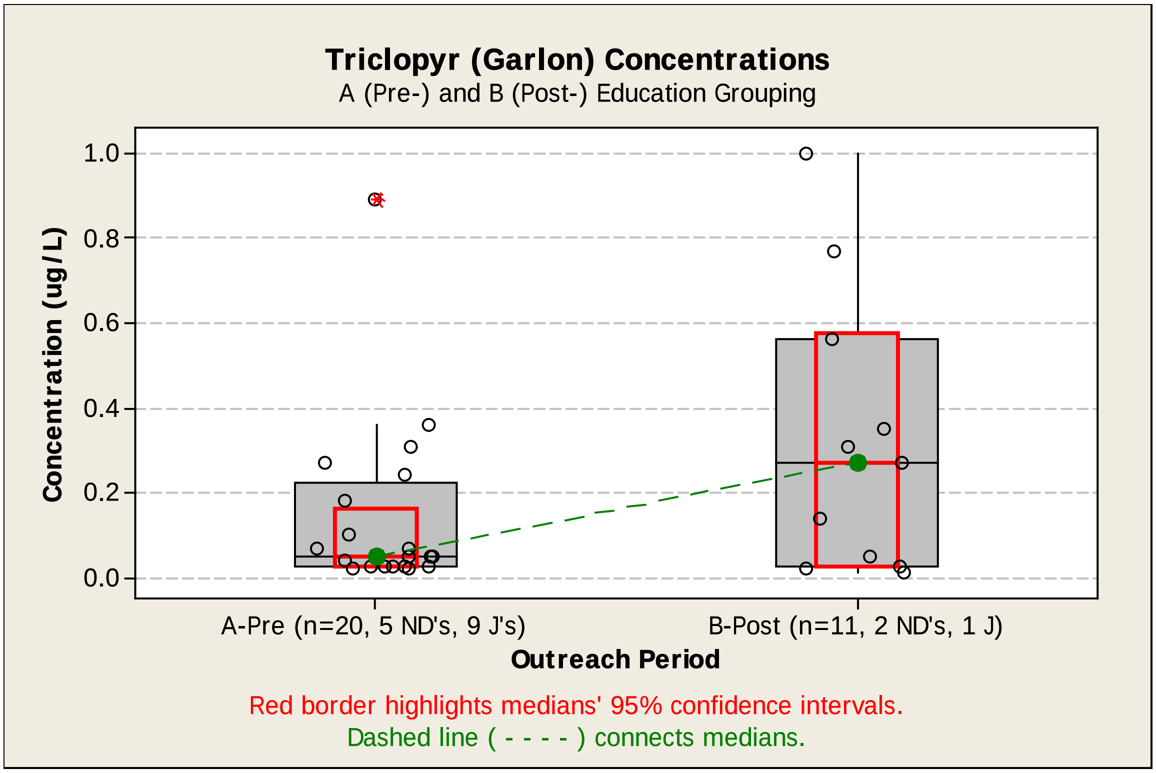


**Figure 26 Storm triclopyr (Garlon) concentration boxplots**

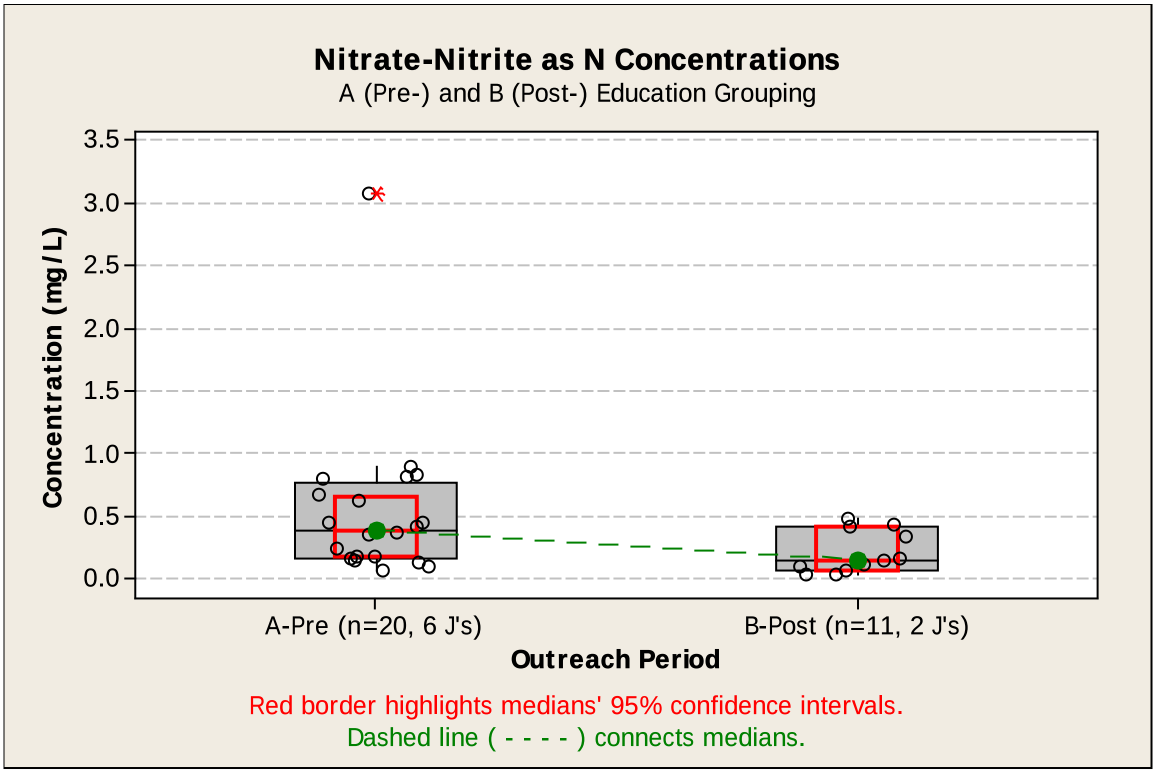


**Figure 27 Storm nitrate-nitrite as N concentration boxplots**

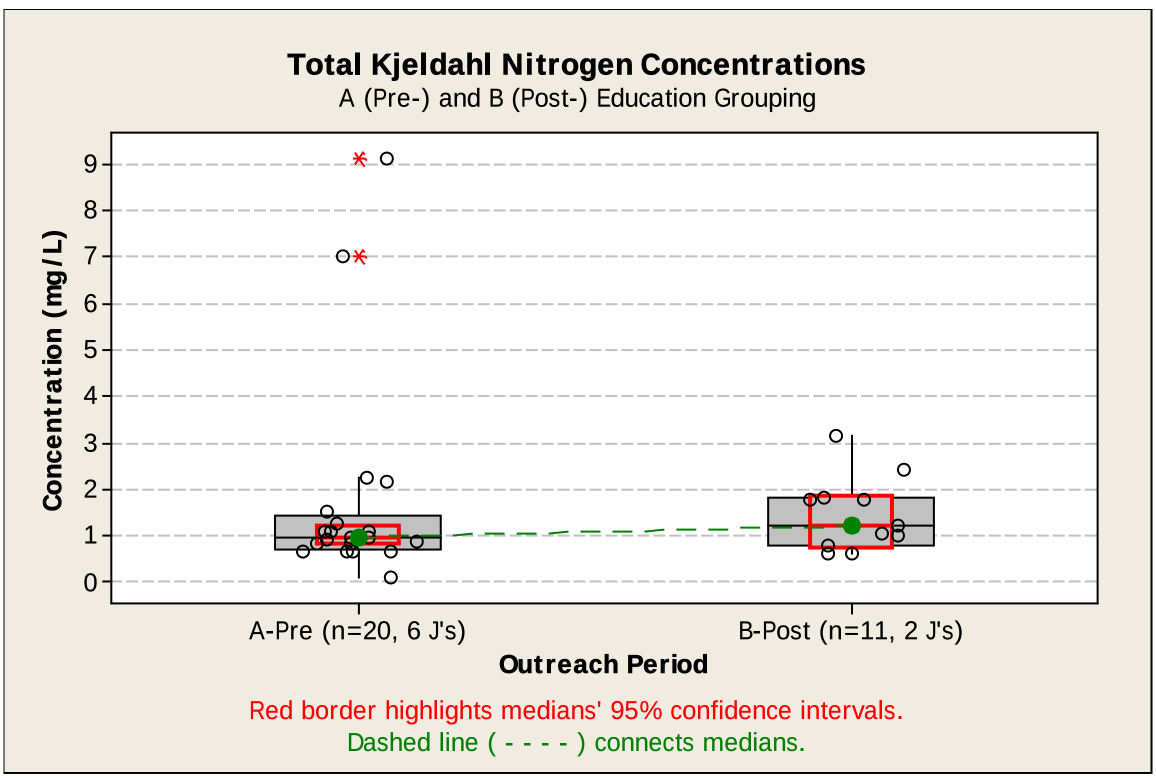


**Figure 28 Storm total Kjeldahl nitrogen concentration boxplots**

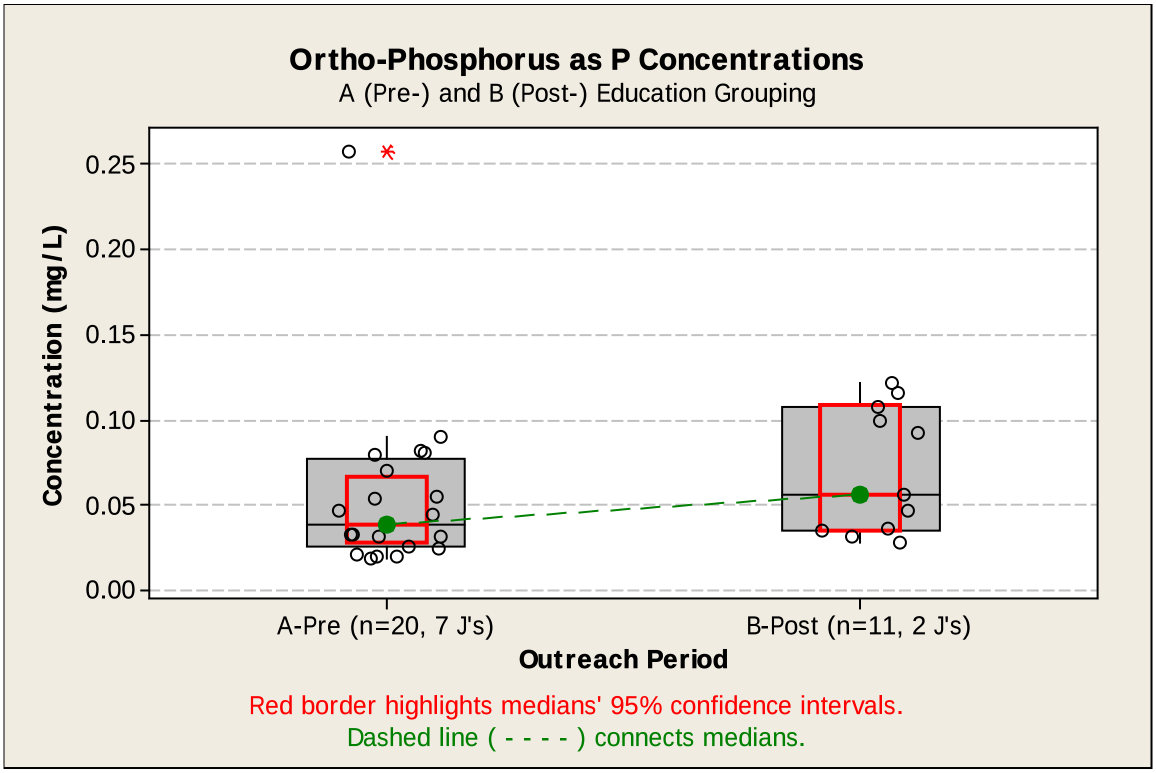


**Figure 29 Storm ortho-phosphorus concentration boxplots**

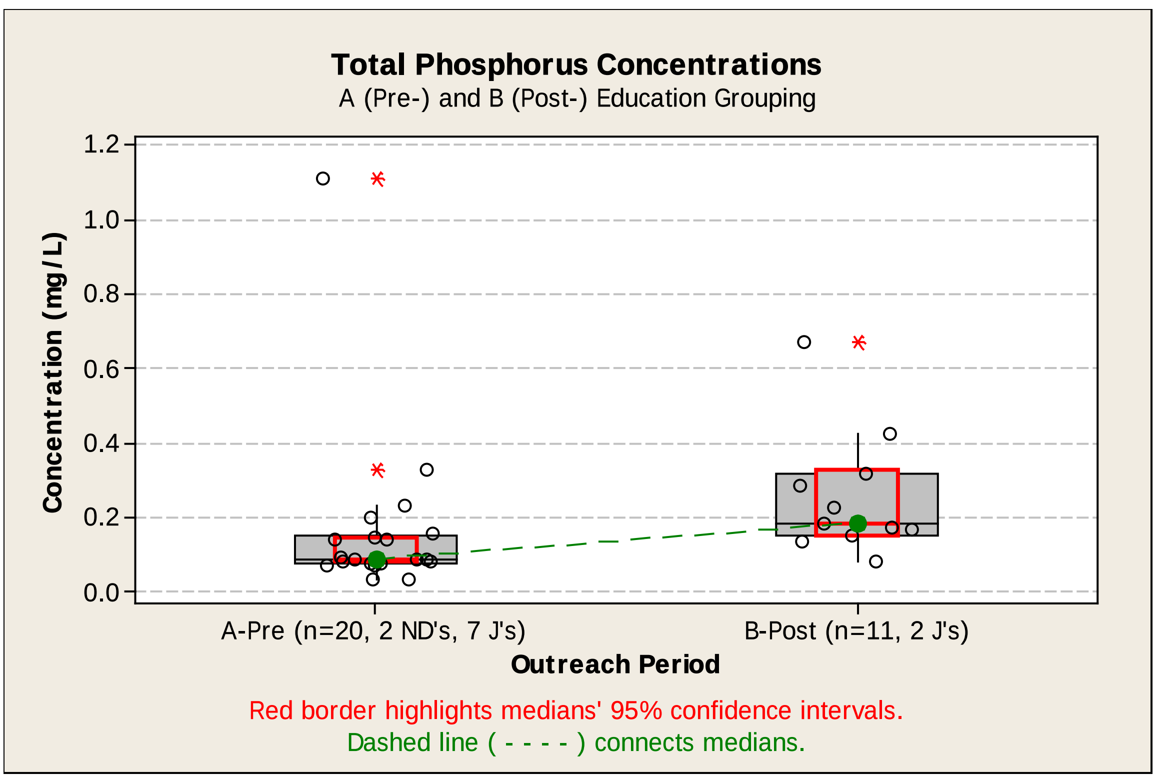


**Figure 30 Storm total phosphorus concentration boxplots**

## Load Boxplots

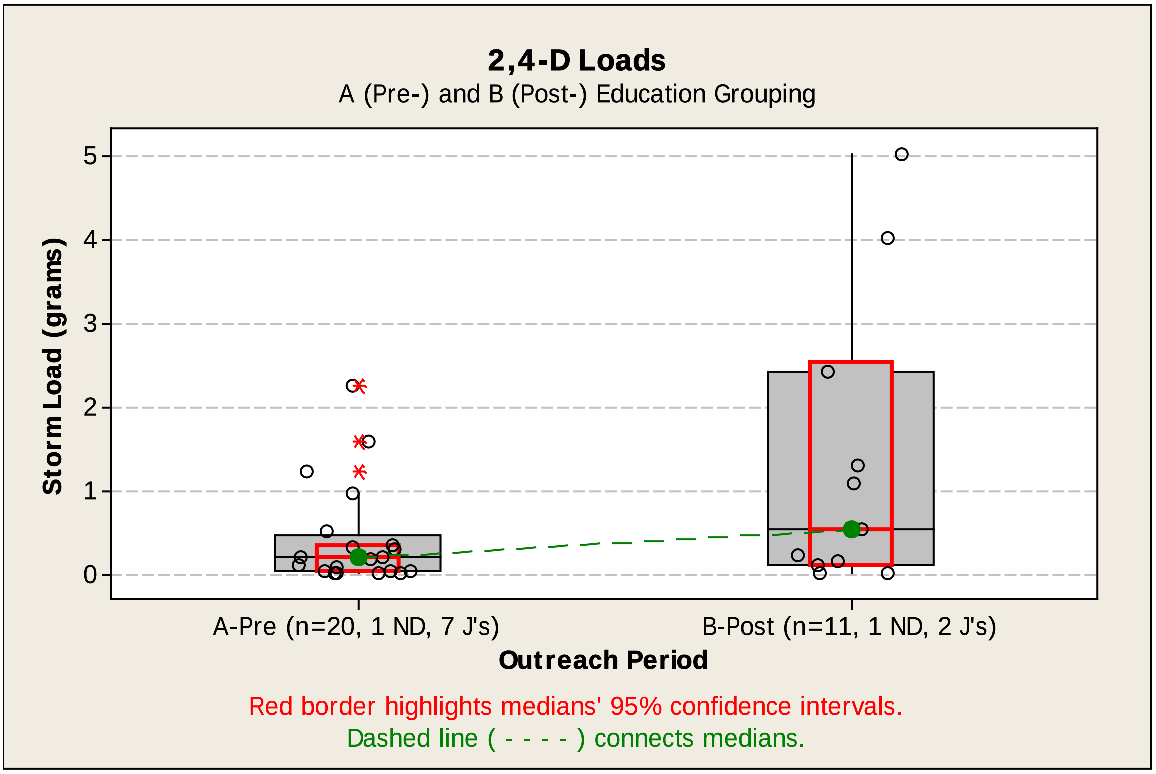


**Figure 31 Storm 2,4-D load boxplots**

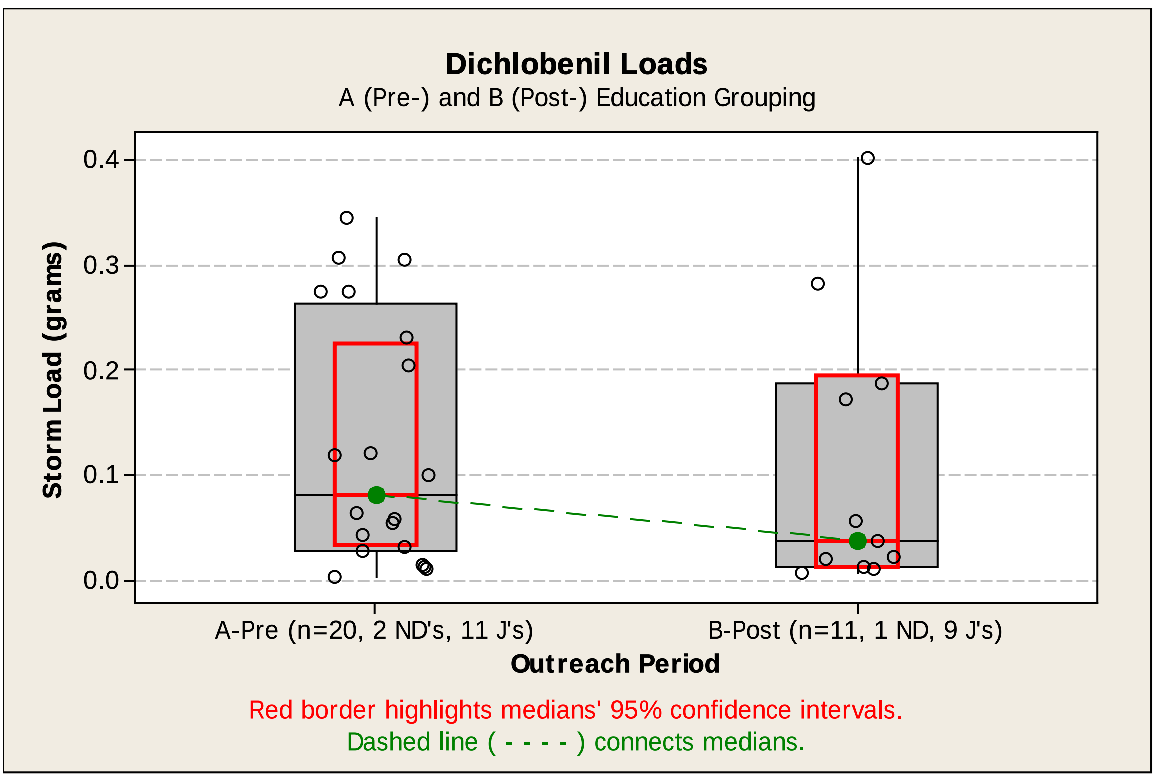


**Figure 32 Storm dichlobenil load boxplots**

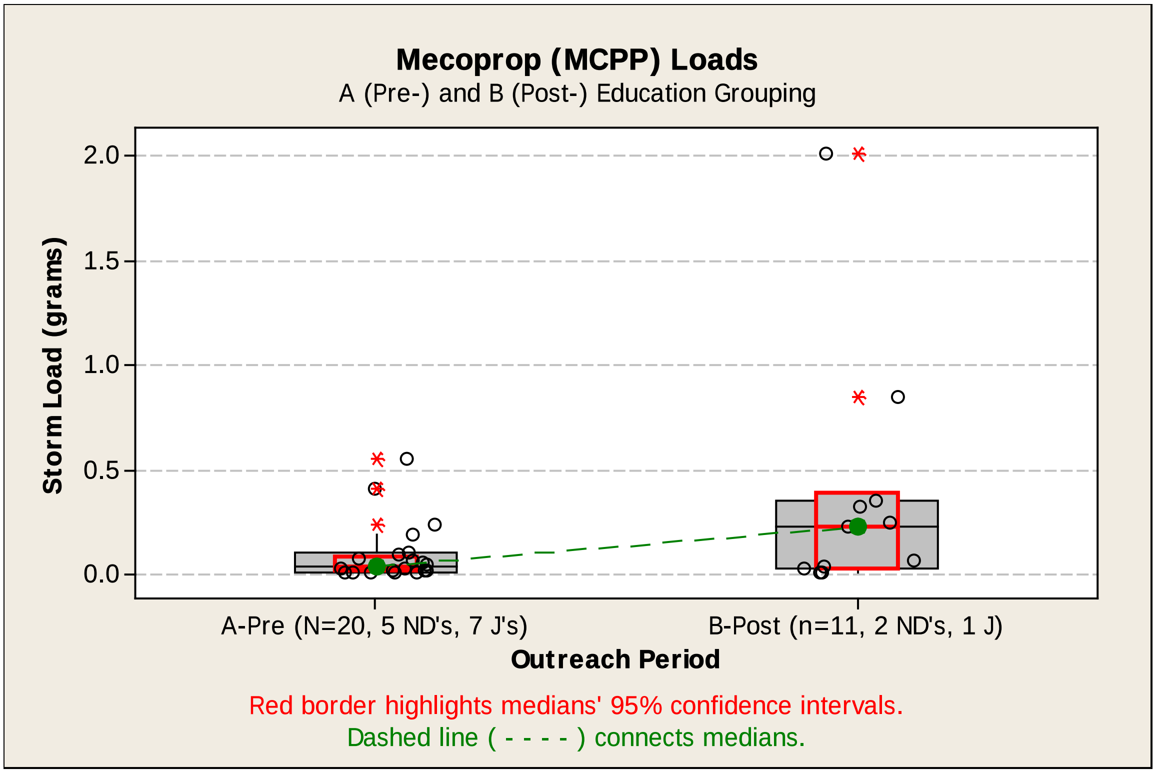


**Figure 33 Storm mecoprop (MCPP) load boxplots**

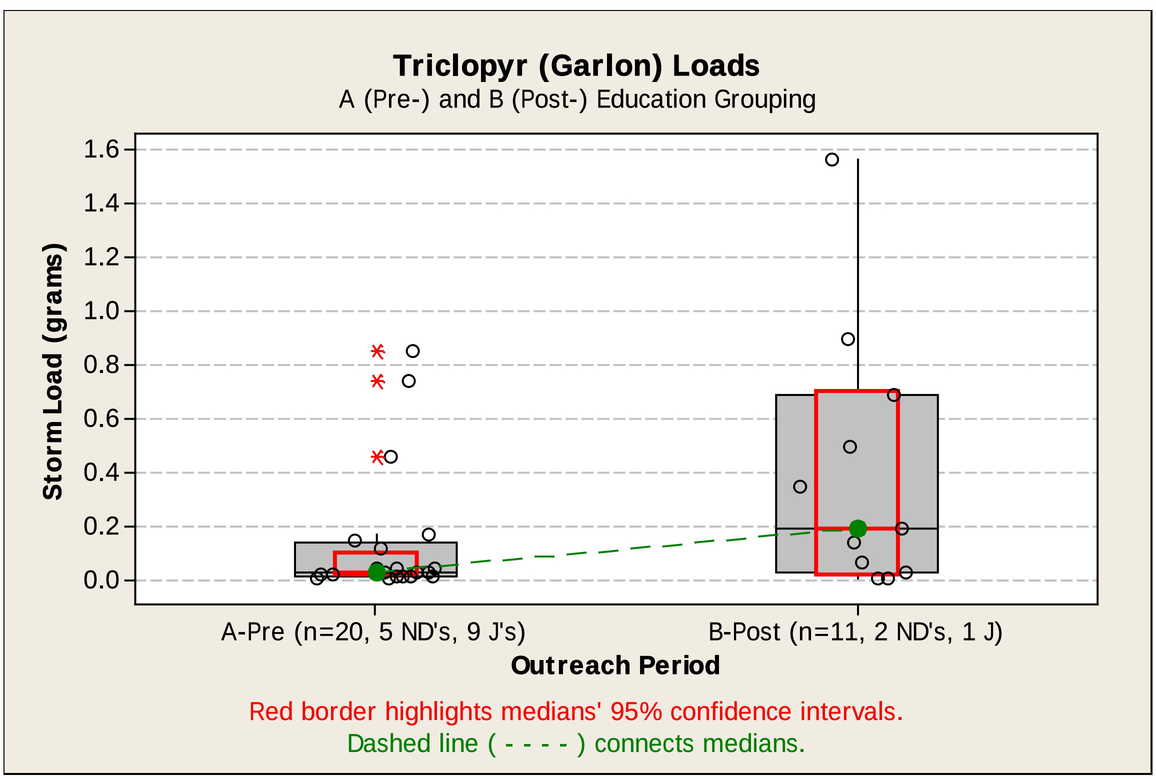


**Figure 34 Storm triclopyr (Garlon) load boxplots**

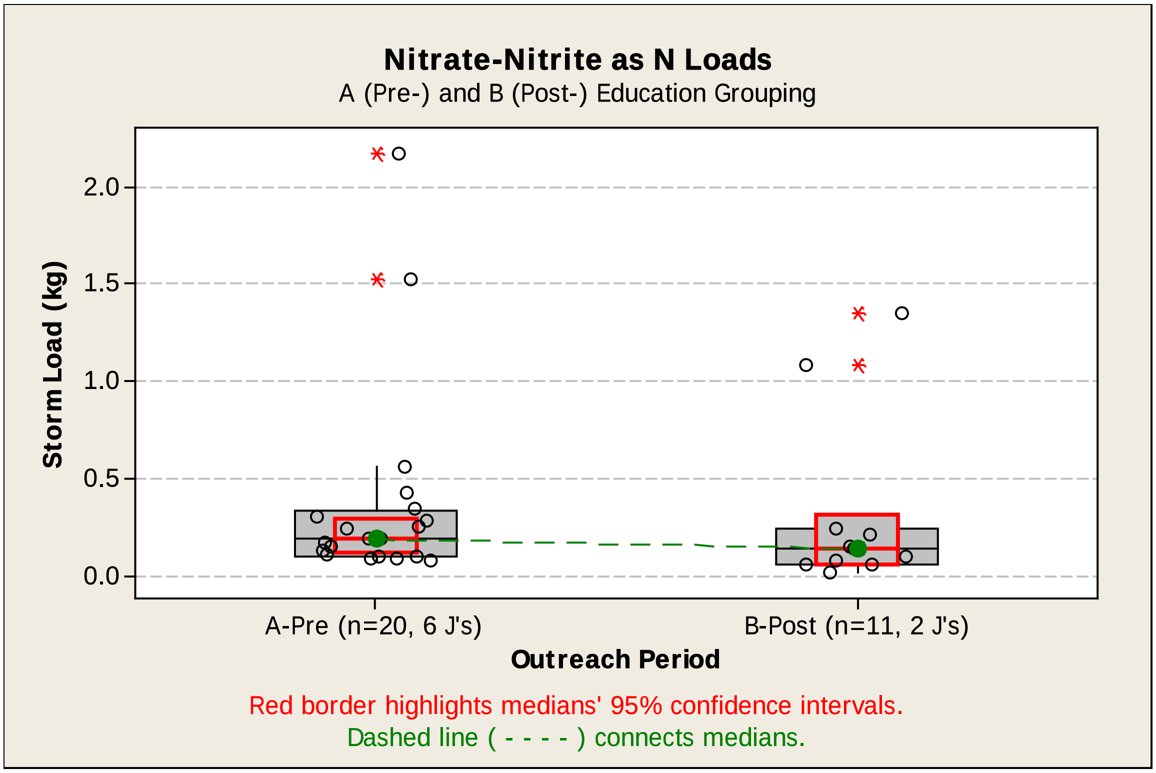


**Figure 35 Storm nitrate-nitrite as N load boxplots**

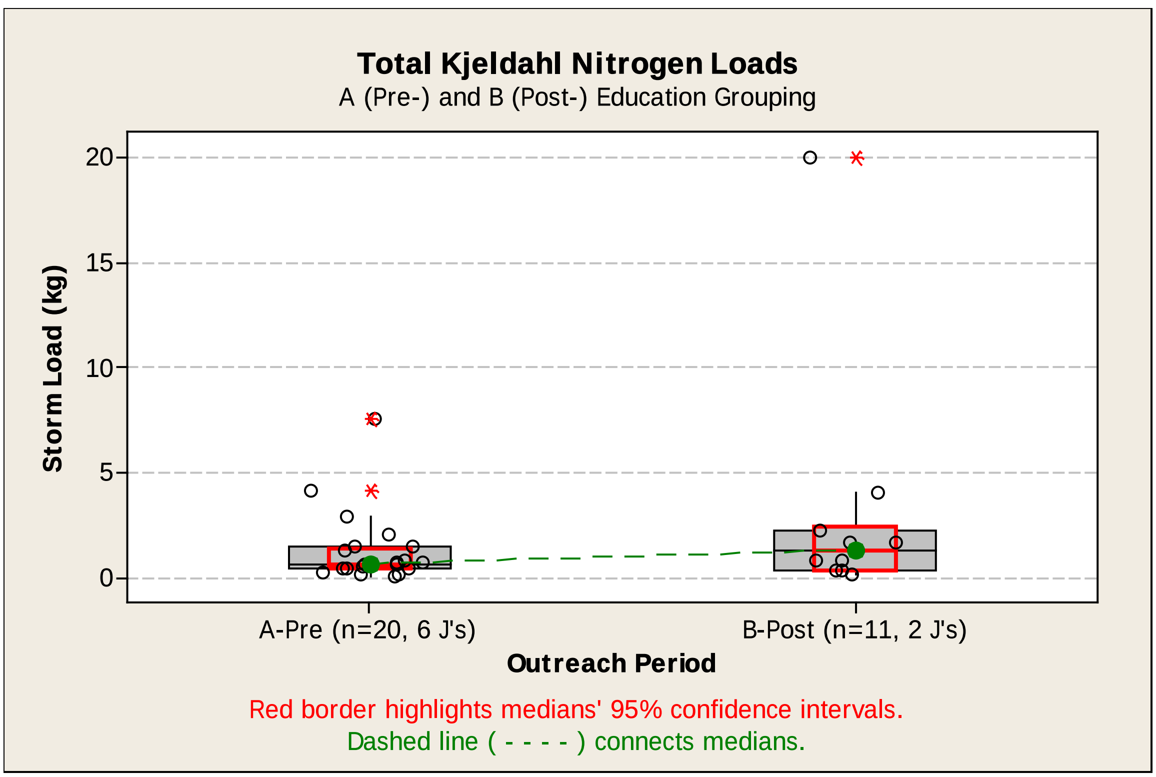


**Figure 36 Storm total Kjeldahl nitrogen load boxplots**

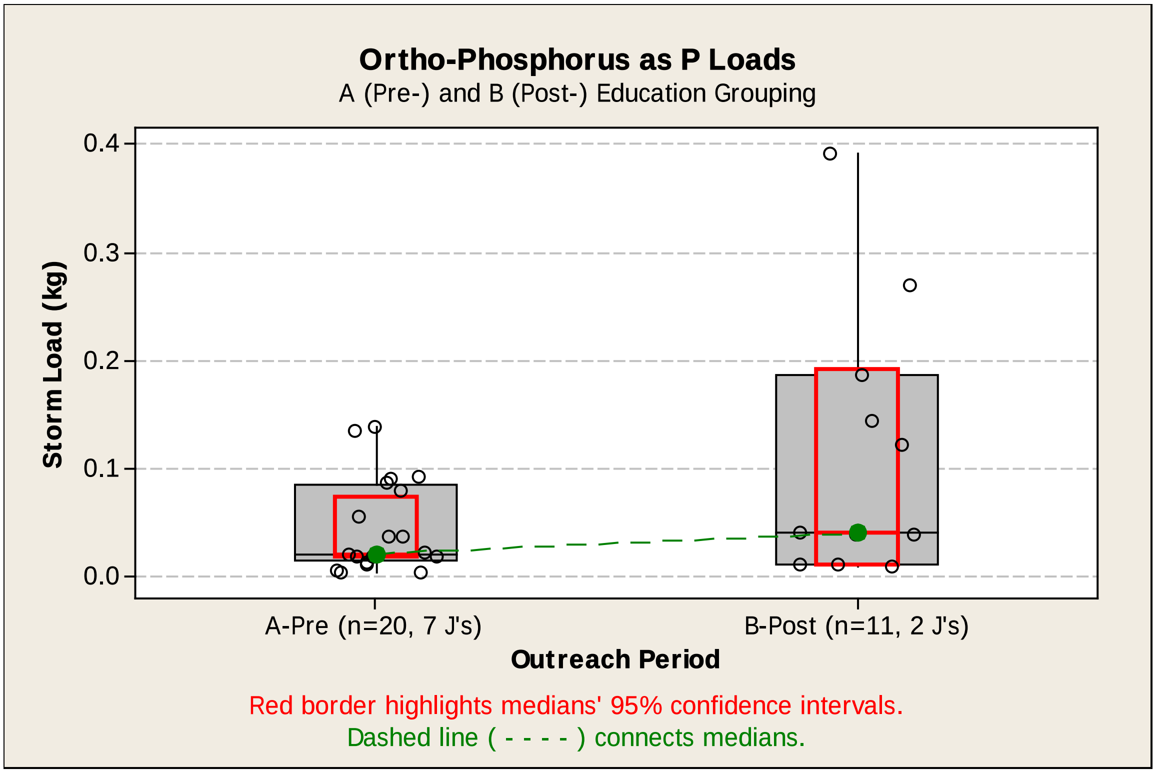


**Figure 37 Storm ortho-phosphorus as P load boxplots**

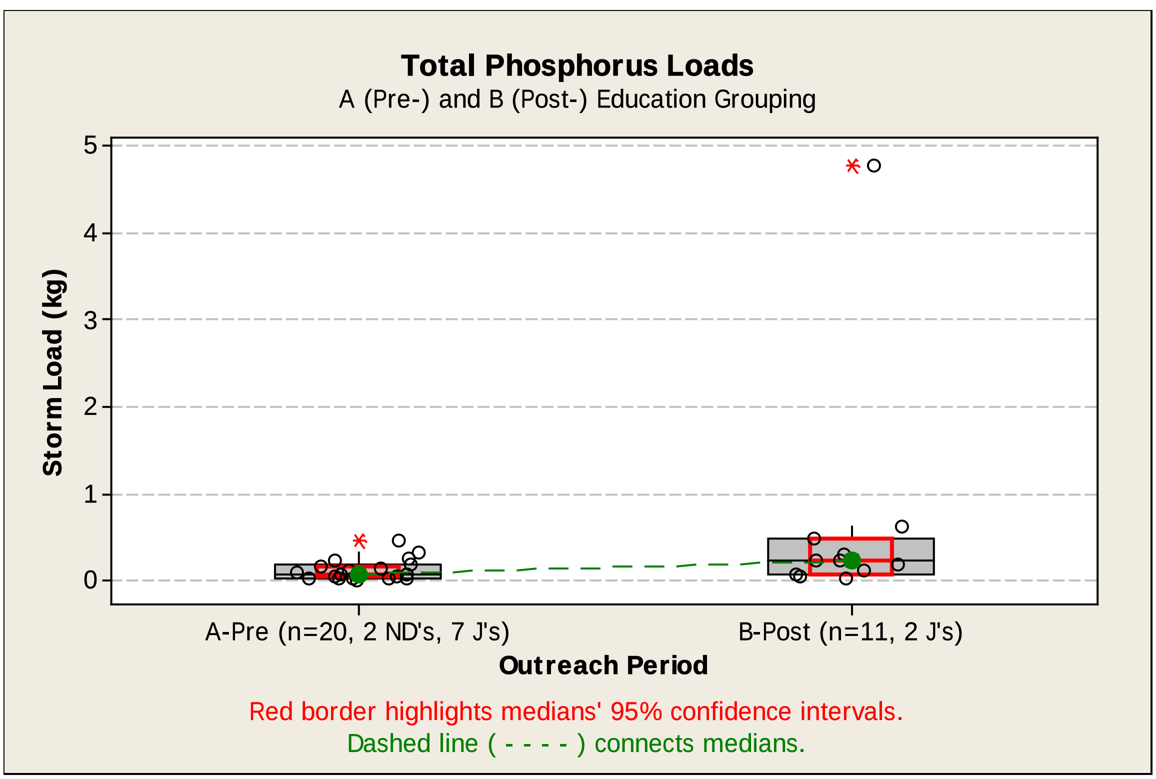


**Figure 38 Storm total phosphorus load boxplots**

## Normality Tests

In order to evaluate statistical tests' assumptions, summary descriptive statistics were calculated and graphics created of HDR's storm concentrations (Appendix 1A) and loads (Appendix 1B) for each of the remaining water quality parameters. The vast majority of these parameter concentrations and loads were not normally distributed (Table 1). Therefore, given the infrequency of normally distributed parameters and the large number of parameters to be evaluated, it was determined to consistently utilize nonparametric statistics for comparing pre- and post- education results.

**Table 1 Normality tests for pre- and post- education storm concentrations and loads**

| PARAMETER | PRE- OR POST EDUCA-TION (SAMPLE SIZE) ~ | CONCENTRATIONS | | | LOADS | | |
|---|---|---|---|---|---|---|---|
| | | Anderson-Darling Normality Test ($A^2$) | P-value | Conclude Normal Distri-bution (based on α of 0.1)~ | Anderson-Darling Normality Test ($A^2$) | P-value | Conclude Normal Distri-bution (based on α of 0.1)~ |
| 2,4-D | Pre (20) | 2.25 | <0.005 | No | 2.35 | <0.005 | No |
| | Post (11) | 0.65 | 0.065 | No | 0.99 | 0.008 | No |
| Dichlobenil | Pre (20) | 2.33 | <0.005 | No | 1.13 | <0.005 | No |
| | Post (11) | 0.98 | 0.009 | No | 1.01 | 0.007 | No |
| Mecoprop (MCPP) | Pre (20) | 1.30 | <0.005 | No | 2.58 | <0.005 | No |
| | Post (11) | 0.92 | 0.013 | No | 1.51 | <0.005 | No |
| Triclopyr (Garlon) | Pre (20) | 2.55 | <0.005 | No | 3.63 | <0.005 | No |
| | Post (11) | 0.57 | 0.107 | Yes | 0.74 | 0.036 | No |
| Nitrate-Nitrite as N | Pre (20) | 2.26 | <0.005 | No | 3.48 | <0.005 | No |
| | Post (11) | 0.62 | 0.079 | No | 1.84 | <0.005 | No |
| Total Kjeldahl Nitrogen | Pre (20) | 3.82 | <0.005 | No | 2.35 | <0.005 | No |
| | Post (11) | 0.42 | 0.269 | Yes | 2.33 | <0.005 | No |
| Ortho-Phosphorus as P | Pre (20) | 2.14 | <0.005 | No | 1.37 | <0.005 | No |
| | Post (11) | 0.67 | 0.057 | No | 0.75 | 0.036 | No |
| Total Phosphorus | Pre (20) | 3.76 | <0.005 | No | 1.21 | <0.005 | No |
| | Post (11) | 0.74 | 0.038 | No | 2.64 | <0.005 | No |

~ The small sample sizes, especially the post education monitoring period's 11 samples, likely reduce the power of this normality test and increase the risk of incorrectly concluding normally distributed data (i.e., Type II error for shaded "Yes" cells above). Also, "failure to reject the null hypothesis ($H_o$: data are normally distributed), however, does not prove that the data do follow a normal distribution, especially for small sample sizes. It simply says normality cannot be rejected with the evidence at hand. Use of a larger alpha-level (say α = 0.1) will increase the power to detect non-normality, especially for small sample sizes, and is recommended when testing for normality" (Helsel and Hirsch, p. 113).

Parametric statistical tests assume that the data have a particular distribution, usually a normal distribution (Helsel and Hirsch, 2000, pp. 100-102). However, if the data do not follow the assumed distribution the resulting test can easily reach an incorrect conclusion. The power of parametric test to reject a null hypothesis when it is false can be quite low when applied to non-normal data. Nonparametric tests do not require the assumption that data follow a particular distribution. Information is extracted by comparing the ranks of the data rather than using summary information from parametric test statistics computed from parameters such as the mean and standard deviation. If data are expected to be non-normal, or not enough is known to assume any specific distribution, nonparametric test would be preferred. Additionally, nonparametric tests are particularly appropriate for small data sets unless experience supports the assumption of normality.

## Pre- and Post- Education Water Quality Medians Statistical Tests

For formal statistical test comparisons of water quality, the pre- and post- education campaign groups of HDR water quality monitoring results are considered to be two independent, unpaired groups. The Mann-Whitney test (also called the rank-sum or Wilcoxon rank-sum test) is an accepted nonparametric procedure for determining whether two independent groups differ (Helsel and Hirsch, p. 117).The data are independent because "there is no natural structure in the order of observations across groups – there are no pairings of data between observation 1 of group 1 and observation 1 of group 2, etc. In some cases it is known ahead of time which group is expected to be larger (a one-sided test) and in other cases it is not (a two-sided test)".

For the applicable HDR concentration and load data, both one-sided tests (greater than as well as less than) comparing the median values for pre- and post- education campaign water quality results were performed using separate Mann-Whitney tests (Table 2 and Table 3). This was done because there was an interest in determining whether values decreased or even increased between the two periods of HDR monitoring.

The rank-sum test requires no assumptions about how the data are distributed in either group being compared (distribution-free, for example not requiring normal distributions) and the data only need be similar except for their central location (Helsel and Hirsch, 1992, pp. 118-123). The rank-sum test compares the sum of each group's combined or joint ranks between the two groups and can correct for tied ranks. Specifically, the rank-sum test can be used to determine whether two groups come from the same population (same median and other percentiles), or alternatively whether they differ only in location (central value or median). If both groups of data are from the same population, about half of the time an observation from either group could be expected to be higher than that from the other. When both groups have sample sizes greater than 10, the large-sample approximation of the rank-sum test statistic distribution (which closely approximates the normal distribution – but does not imply the original data are normally distributed) is used by statistical software in determining p-values for statistical tests.

Use of the rank-sum test for comparing pre- and post- education campaign HDR water quality data is also supported in order to address the amount of data censoring still remaining after limiting the analyses to after 2010 to initially help narrow the range of nondetect values analyzed. "When there is only one reporting limit, standard (ordinal) nonparametric tests such as the rank-sum test can be computed directly from the data. When the test converts data to their ranks, censored observations are represented as a tied rank lower than the rank for the lowest detected observation. These ranks will efficiently capture the information in the data, including the proportion of censored observations, accurately representing what is actually known about the data. Test results are reliable, not based on 'information' that is not known, and not dependent on the substitution of arbitrary values (Helsel, 2012, p.58)."

**Table 2 Mann-Whitney rank-sum statistical tests of differences in the Pre- and Post- Education Periods' HDR Water Quality Parameters Concentration Medians**

| Parameter ~ (conc. units) [Pesticide Use: H- Herbicide, F- Fungicide, I- Insecticide] | Pre- or Post- Edu-cation | HDR Sample Size (Percent Detects) | Concentrations: One-sided Tests of the Significance in Differences of the Pre- and Post- Education Period's HDR Parameter Medians (based on $H_o$: Pre-median = Post-median, α of 0.05) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Median of Storms' Concs. | Point Estimate for Pre- minus Post- Medians (Actual % change) | 95% Confidence Interval for Point Estimate of Difference in Medians | Calculated Mann-Whitney Rank Sum Test Statistic (W) | $H_1$:Pre- > Post- Signif., P-value or Versus Approx. W* | $H_1$:Pre- < Post- Signif., P-value or Versus Approx. W* |
| **Pesticides** | | | | | | | | |
| 2,4,- D (ug/L) [H] | Pre | 20 (95%) | 0.28 | -0.083 (61% ↑) | -1.23, 0.17 | 300.0 | No, W <320 | No, 0.2102 |
| | Post | 11 (91%) | 0.45 | | | | | |
| Dichlobenil (ug/L) [H] | Pre | 20 (90%) | 0.08 | 0.0355 (50% ↓) | 0.003, 0.170 | 373.5 | Yes, 0.0143 | No, W >320 |
| | Post | 11 (91%) | 0.04 | | | | | |
| Mecoprop (ug/L) [H] | Pre | 20 (75%) | 0.06 | -0.04 (200%↑) | -0.17, 0.04 | 291.5 | No, W <320 | No, 0.1231 |
| | Post | 11 (82%) | 0.18 | | | | | |
| Triclopyr (ug/L) [H] | Pre | 20 (75%) | 0.05 | -0.105 (440% ↑) | -0.30, 0.015 | 291.0 | No, W <320 | No, 0.1184 |
| | Post | 11 (82%) | 0.27 | | | | | |
| *Prometon ~* (ug/L) [H] | Pre | 20 (20%) | NA | NA | NA | NA | NA | NA |
| | Post | 11 (9%) | NA | | | | | |
| *Pentachlorophenol~* (ug/L) [F] | Pre | 20 (25%) | NA | NA | NA | NA | NA | NA |
| | Post | 11 (18%) | NA | | | | | |
| *Chlorpyrifos ~* (ug/L) [I] | Pre | 20 (0%) | NA | NA | NA | NA | NA | NA |
| | Post | 7 (0%) | NA | | | | | |
| *Diazinon ~* (ug/L) [I] | Pre | 20 (0%) | NA | NA | NA | NA | NA | NA |
| | Post | 11 (0%) | NA | | | | | |
| *Malathion ~* (ug/L) [I] | Pre | 20 (0%) | NA | NA | NA | NA | NA | NA |
| | Post | 7 (0%) | NA | | | | | |
| **Nutrients** | | | | | | | | |
| Nitrate-Nitrite as N (mg/L) | Pre | 20 (100%) | 0.392 | 0.1925 (61% ↓) | 0.017, 0.4181 | 375.0 | Yes, 0.0122 | No, W >320 |
| | Post | 11 (100%) | 0.151 | | | | | |
| Total Kjeldahl Nitrogen (mg/L) | Pre | 20 (100%) | 0.97 | -0.19 (24% ↑) | -0.860, 0.301 | 303.0 | No, W <320 | No, 0.2478 |
| | Post | 11 (100%) | 1.20 | | | | | |
| Ortho-Phosphorus as P (mg/L) | Pre | 20 (100%) | 0.039 | -0.0155 (44% ↑) | -0.053, 0.004 | 276.5 | No, W <320 | Yes, 0.0378 |
| | Post | 11 (100%) | 0.056 | | | | | |
| Total Phosphorus (mg/L) | Pre | 20 (90%) | 0.089 | -0.0915 (108% ↑) | -0.193, -0.030 | 258.0 | No, W <320 | Yes, 0.0055 |
| | Post | 11 (100%) | 0.185 | | | | | |

~ Some pesticides had the majority of their results as nondetects (in italics above). For parameters with more than 70% censored data, no summary statistics were calculated nor were statistical tests performed on median differences due to likely poor estimates (See Antweiler and Taylor, 2008). Early higher lab non-detect limits were addressed by only evaluating results with more consistent nondetects after January 2011.

* Not all differences in medians have estimated p-values provided by MiniTab. If the calculated test statistic W is less than or greater than (depending on direction of comparison) the statistical software's large-sample approximation of normally distributed W test statistic, the calculated W is instead compared with the applicable approximate W. Where applicable, p-values reflect adjustments for tied ranks.

**Table 3 Mann-Whitney rank-sum statistical tests of differences in the Pre- and Post- Education Periods' HDR Water Quality Parameters Load Medians**

| Parameter ~ (load units) [Pesticide Use: H- Herbicide, F- Fungicide, I- Insecticide] | Pre- or Post- Edu-cation | HDR Sample Size (Percent Detects) | Loads: One-sided Tests of the Significance in Differences of the Pre- and Post- Education Period's HDR Parameter Medians (based on $H_o$: Pre-median = Post-median, α of 0.05) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Median of Storms' Loads** | **Point Estimate for Pre- minus Post- Medians (Actual % change)** | **95% Confidence Interval for Point Estimate of Difference in Medians** | **Calculated Mann-Whitney Rank Sum Test Statistic (W)** | **$H_1$:Pre- > Post- Signif., P-value or Versus Approx. W*** | **$H_1$:Pre- < Post- Signif., P-value or Versus Approx. W*** |
| **Pesticides** | | | | | | | | |
| 2,4,- D (g) [H] | Pre | 20 (95%) | 0.20 | -0.210 (170% ↑) | -1.269, 0.054 | 288.0 | No, W <320 | No, 0.0967 |
| | Post | 11 (91%) | 0.54 | | | | | |
| Dichlobenil (g) [H] | Pre | 20 (90%) | 0.08 | 0.0205 (50% ↓) | -0.0452, 0.1015 | 341.0 | No, 0.1987 | No, W >320 |
| | Post | 11 (91%) | 0.04 | | | | | |
| Mecoprop (g) [H] | Pre | 20 (75%) | 0.04 | -0.0613 (475%↑) | -0.2879, 0.0111 | 283.0 | No, W <320 | No, 0.0659 |
| | Post | 11 (82%) | 0.23 | | | | | |
| Triclopyr (g) [H] | Pre | 20 (75%) | 0.03 | -0.1244 (533% ↑) | -0.4641, 0.0068 | 281.0 | No, W <320 | No, 0.0560 |
| | Post | 11 (82%) | 0.19 | | | | | |
| *Prometon ~* (g) [H] | Pre | 20 (20%) | NA | NA | NA | NA | NA | NA |
| | Post | 11 (9%) | NA | | | | | |
| *Pentachlorophenol ~* (g) [F] | Pre | 20 (25%) | NA | NA | NA | NA | NA | NA |
| | Post | 11 (18%) | NA | | | | | |
| *Chlorpyrifos ~* (g) [I] | Pre | 20 (0%) | NA | NA | NA | NA | NA | NA |
| | Post | 7 (0%) | NA | | | | | |
| *Diazinon ~* (g) [I] | Pre | 20 (0%) | NA | NA | NA | NA | NA | NA |
| | Post | 11 (0%) | NA | | | | | |
| *Malathion ~* (g) [I] | Pre | 20 (0%) | NA | NA | NA | NA | NA | NA |
| | Post | 7 (0%) | NA | | | | | |
| **Nutrients** | | | | | | | | |
| Nitrate-Nitrite as N (kg) | Pre | 20 (100%) | 0.185 | 0.0554 (26% ↓) | -0.0456, 0.1784 | 355.0 | No, 0.0772 | No, W >320 |
| | Post | 11 (100%) | 0.136 | | | | | |
| Total Kjeldahl Nitrogen (kg) | Pre | 20 (100%) | 0.68 | -0.293 (96% ↑) | -1.204, 0.366 | 292.0 | No, W <320 | No, 0.1281 |
| | Post | 11 (100%) | 1.33 | | | | | |
| Ortho-Phosphorus as P (kg) | Pre | 20 (100%) | 0.021 | -0.0253 (81% ↑) | -0.1254, 0.0082 | 284.0 | No, W <320 | No, 0.0714 |
| | Post | 11 (100%) | 0.040 | | | | | |
| Total Phosphorus (kg) | Pre | 20 (90%) | 0.070 | -0.116 (217% ↑) | -0.244, 0.000 | 273.0 | No, W <320 | Yes, 0.0274 |
| | Post | 11 (100%) | 0.222 | | | | | |

~ Some pesticides had the majority of their results as nondetects (in italics above). For parameters with more than 70% censored data, no summary statistics were calculated nor were statistical tests performed on median differences due to likely poor estimates (See Antweiler and Taylor, 2008). Early higher lab non-detect limits were addressed by only evaluating results with more consistent nondetects after January 2011.

* Not all differences in medians have estimated p-values provided by MiniTab. If the calculated test statistic W is less than or greater than (depending on direction of comparison) the statistical software's large-sample approximation of normally distributed W test statistic, the calculated W is instead compared with the applicable approximate W. Where applicable, p-values reflect adjustments for tied ranks.

The rank-sum test results show that only two of the thirteen monitored parameters, herbicide dichlobenil and nutrient nitrate-nitrite as N, had statistically significant decreases in their median concentration values from the pre- to post- education periods (Table 2). However, it is important to note that 5 (55%) of the 9 monitored pesticides each had more than 70% of their respective concentration results as non-detects which did not allow meaningful statistical comparison between their medians. These common results suggest that for these pesticides both their pre- and post- education concentration values were very low and probably approaching irreducible concentrations.

While dichlobenil's 50% decrease in its median concentrations from pre- (0.08 ug/L) to post- (0.04 ug/L) education periods was statistically significant (Table 2), only 7 (35%) of its 20 pre- and 1 (10%) of its 11 post- education results were above their method reporting limits. This also suggests very low concentrations often occur for this herbicide. The two highest post-2010 dichlobenil concentrations (0.67 ug/L for May 12, 2011 and 0.68 ug/L for March 6, 2012, also see Figure 8 ) both occurred during the spring time during the pre-education period. Of the these two highest dichlobenil values, only the first value is substantially higher (by about a factor of 7) than the lab's respective method reporting limits (MRL) of 0.098 ug/L while the other is only 1.4X its 0.50 ug/L MRL on the dates of analyses. Additionally, both of these 0.67 and 0.68 highest post-2010 monitored dichlobenil concentrations are within Ecology's 2007 NPDES Stormwater Permit Appendix 9's method reporting limit target range of 0.01 – 1.0 ug/L for dichlobenil which also suggests their relatively low values.

Differences in Nitrate-Nitrite as N median concentrations (Table 2), the only other monitored parameter with significant decreases between its pre- and post- education periods, do appear to be supported by a group of higher values during the first half of 2011. During this pre- education period many of the values appear to be about twice the post- education values except for one much higher outlier 3.09 mg/L value from June 28, 2011 (see Figure 14). Unlike the pesticides, most of the concentration results for all the nutrients are above their method reporting limits and therefore justify a higher level of confidence in the accuracy of these nutrient results.

The rank-sum test results showing statistically significant increases in the medians between pre- and post- education periods for both ortho-phosphorus as P and total phosphorus concentrations (Table 2) are supported by their individual results. Many of the post- period values are at least double those of many pre- period values except for pre- education period high outliers (Figure 16 and Figure 17).

All of HDR's pre- and post- education median nutrient concentrations appeared to be lower than those found nationally (Table 4). While not statistically tested, the HDR nutrient medians appear substantially less than those from National Stormwater Quality Database's (NSQD) large data set for residential land uses. However, the NSQD medians do not include any non-detect values in their calculations whereas the HDR medians do include one-half of non-detect substitutions. While this substitution would tend to decrease HDR's medians compared to those for NSQD, the impact of this is likely very small because the lowest percentages of detects were 90% for HDR and 84% for NSQD. Importantly, some NSQD constituents, such as filtered heavy metals and especially organics (including pesticides) were mostly all not detected and are not summarized in the NSQD by land use category (Pitt, et.al., 2004, p. 5).

**Table 4 Nutrient concentration comparisons: HDR pre- and post- education and NSQD residential median concentrations, sample sizes, and percent detects**

| Nutrient Parameter | HDR Pre- or Post- Education | HDR Sample Size (% Detects) | HDR Median of Storms' Concs. (mg/L) | HDR Median Storms' Concs. as a Percent of NSQD Residential Median Concentration (%) | NSQD: Residential Land Use Median Concentrations, Sample Size, and % Detects * |
|---|---|---|---|---|---|
| Nitrate-Nitrite as N | Pre | 20 (100%) | 0.392 | 65% | 0.60 mg/L, n=889, 97.6% |
| | Post | 11 (100%) | 0.151 | 25% | |
| Total Kjeldahl Nitrogen | Pre | 20 (100%) | 0.965 | 64% | 1.5 mg/L, n=922, 96.5%, |
| | Post | 11 (100%) | 1.200 | 80% | |
| Ortho-Phosphorus as P | Pre | 20 (100%) | 0.039 | 21% | 0.18 mg/L, n=690, 83.5% |
| | Post | 11 (100%) | 0.056 | 31% | |
| Total Phosphorus | Pre | 20 (90%) | 0.089 | 29% | 0.31 mg/L, n=926, 96.8% |
| | Post | 11 (100%) | 0.185 | 60% | |

*Source: National Stormwater Quality Database (NSQD version 1.1 updated April 30, 2005) summary of storm event observations by land use categories. NSQD median values are only calculated from data having detected concentrations.

The only statistically significant difference found in the medians of loads from pre- to post education periods for all the monitored parameters was an increase for total phosphorus (Table 3). While the more powerful rank-sum test indicated this statistically significant increase between periods, there is an overlap in their total phosphorus loads respective box plots' internal red boxes (depicting the 95% confidence interval around each period's total phosphorus load median) that suggest the difference in medians is not substantial or of practical significance. One very high total phosphorus load outlier value of 4.7 kg for the September 21, 2013 monitored event was driven by the second highest monitored total phosphorus concentration of 0.668 mg/L and a very high storm volume of 11 million liters or 5 times higher than the next highest monitored storm volume.

Generally, the water quality monitored storm volumes were similar for the pre- and post-education periods and their median values did not appear to be significantly different (Figure 39). The overall similarity (except for the September 21, 2013 outlier noted above) in the two periods' storm volumes suggests that differences between them are unlikely to be a substantial driver of or confound analyses of differences in load medians.

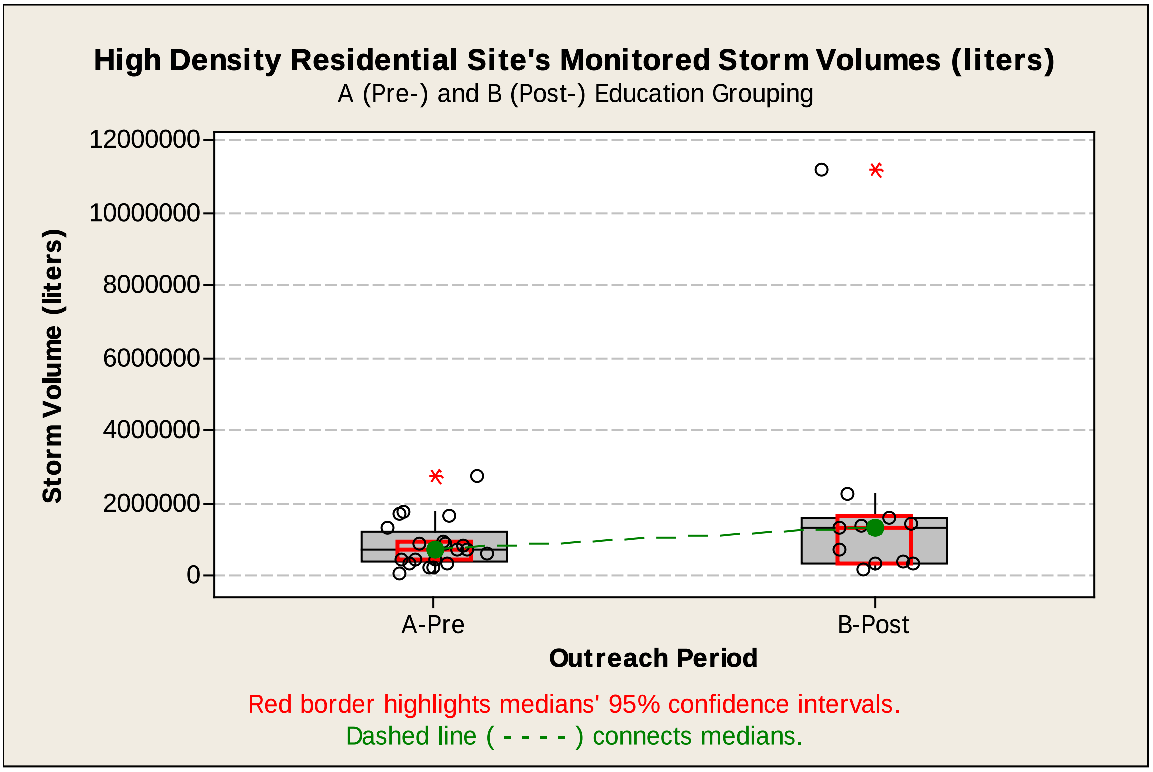


**Figure 39 Pre- and post- education periods' monitored storm volumes.**

## Pre- and Post- Education Sediment Quality

Pesticide concentrations in HDR sediment samples collected at times bracketing the pre- and post- education period are presented in Table 5. These represent pesticide results from cumulative sediment samples collected in carboys deployed for the year prior to their pick up on May 16, 2012 (for the pre- period) and May 20, 2013 (for the post-period). Statistical inferences are not possible given there was only one sample from each period. Percent change was only calculated for pentachlorophenol because of low confidence in the magnitude of the nondetect results for the three other pesticides. Pentachlorophenol's 69% reduction was also based on very low estimated values for both the pre- and post- education periods. It is important to note that all three sediment monitored insecticides' (chlorpyrifos, diazinon, and malathion) uniformly very low non-detect results (represented by subsequently substituted one-half their lab reported detection limits values) in the table were all less than or equal to their respective Ecology reporting limit targets.

**Table 5 Pre- and Post- education period sediment quality**

| Parameter ~ (conc. units) [Pesticide Use: F- Fungicide, I- Insecticide] | Pre- or Post- Education | HDR Sediment Concentration* | Lab Reported Nondetect (ND) or Estimated (J)* | Percent Change and Direction* | Ecology's Reporting Limit Target |
|---|---|---|---|---|---|
| Pentachlorophenol~ (ug/kg) [F] | Pre | 8 | J | 69% ↓ | 1.0 ug/kg |
| | Post | 2.5 | J | | |
| Chlorpyrifos ~ (ug/kg) [I] | Pre | 25 | ND | NA | 25 ug/kg |
| | Post | 18 | ND | | |
| Diazinon ~ (ug/kg) [I] | Pre | 25 | ND | NA | 50 ug/kg |
| | Post | 18 | ND | | |
| Malathion ~ (ug/kg) [I] | Pre | 18 | ND | NA | 25 ug/kg |
| | Post | 13 | ND | | |

*Laboratory reported nondetect results have been replaced with one-half of method detection limit values for basic comparison purposes. Percent changes are only presented for pentachlorophenol's estimated results because there is low confidence in the magnitude of all the other pesticides' nondetect results. Sediment samples were not analyzed for the nutrient total phosphorus.

# Quality Assurance / Quality Control

Field quality assurance / quality control (QA / QC) procedures followed those described in the latest S8D and S8E Quality Assurance Project Plans / QAPPs (Clark County, Quality Assurance Project Plans for Stormwater Characterization Monitoring [S8D] and Targeted Stormwater Management Program Effectiveness Monitoring [S8E], 2011). Field and office procedures followed standard operating procedures listed in Table T1 of the S8D QAPP and kept on file in binders in the office. Laboratory procedures followed their internal standard operating procedures and published methods accredited by the Washington State Department of Ecology.

## Field QA / QC

Field and office activities followed documented standard operating procedures that were tailored to each monitoring site. Flow, precipitation, and sampling equipment were maintained according to manufacturers' recommendations.

During sampler set-up visits and sample retrieval, or as needed, a standardized check list of activities were followed and documented on field forms. Rain gages were checked for debris, levelness and proper functioning. Stage sensors readings were compared to actual water surface height and offsets adjusted as needed. Sampler lines were triple rinsed with lab grade water and known test volumes were used to calibrate sampler pump volumes. "Clean hands / dirty hands" procedures were followed as feasible during sampler setup and sample retrieval. Sample composite volumes were compared to expected volumes based on the number of aliquots collected. Composite volumes, carboy counts, and other sample information or observations were documented on field forms. Regular maintenance was performed as needed, such as battery replacement.

Individual field forms were reviewed by the program manager for completeness and accuracy. Any observed issues were addressed as soon as possible. Additionally, the program manager periodically participated in field work to review adherence to standard operating procedures. Procedural issues were addressed as needed, initially with technical assistance from Herrera Environmental Consultants, Inc.

## Laboratory QA / QC

Sample transfer followed standard operating procedures and laboratory activities followed internal standard operating procedures consistent with applicable lab quality assurance programs. Sample bottles were clearly labeled, placed within coolers, and transferred to laboratory delivery personnel while documenting required information on laboratory supplied chain of custody forms. All analyses were performed under contract at the nearby Washington State accredited Columbia Analytical Services (acquired by ALS Environmental in 2012) laboratory in Kelso, Washington (to help meet hold times), except for a few of the analytes at other accredited subcontracted labs. Composite samples were split, as needed, in a laboratory clean room to minimize the possibility of field contamination.

The vast majority of lab analyses achieved QAPP specifications with any deviations flagged and noted in the laboratory supplied report's case narrative (as well as in the associated EDD) for each set of samples submitted. Almost all analyses were performed within prescribed hold times with rare exceptions documented and results addressed according to procedures in the QAPP. Each sample was analyzed according to Ecology approved methods or approved alternative methods and method reporting limits with any deviations documented in the laboratory report. Where applicable, internal laboratory quality control analyses results (e.g. method blanks, surrogate recoveries, laboratory duplicates, matrix spikes, laboratory control samples, etc.) are also provided in the laboratory report along with potential issues described in the case narrative. Laboratory quality control samples met objectives the vast majority of times. As a result, there were relatively few changes needed for individual result's data qualifiers (such as indicating estimated values) and even fewer rejected results.

## QC Sample Results

Quality control samples were collected during the monitoring effort to help evaluate procedures for potential sources of contamination and to examine precision. Specifically, stormwater transport, transfer, stormwater and sediment field equipment blanks, as well as stormwater and sediment replicate / split samples were each collected then analyzed identically as routine samples. All of the S8E stormwater and sediment monitoring parameters are a subset of and collected as part of the S8D stormwater characterization monitoring project as well as ortho-phosphorus and total phosphorus being a subset of the similarly monitored S8F Best Management Practice effectiveness monitoring project. Therefore, to save resources while increasing the number of applicable QC samples and for the purpose of analysis, QC composite samples containing parameters common to these monitoring projects were submitted to the lab and analyzed across all these projects.

During the focused 35-month evaluation period from January 2011 through November 2013, a total of 26 applicable QC composite stormwater samples were collect for both the S8D and S8F monitoring projects (14 replicate/splits, 4 transport, 4 transfer, and 4 equipment rinsate). Of these 26 QC samples, 14 were samples split in the clean environment of the analytical lab in order to evaluate the overall precision of stormwater sampling. Additionally, during the focused evaluation period to evaluate potential sediment sampling bias and precision, one sediment sample collection bottle equipment blank of lab grade deionized water was collected on June 13, 2012 and one replicate sediment sample from the low density residential (LDR) S8D project site was collected on May 20, 2013 then split shortly thereafter at the lab.

In order to evaluate potential bias, field equipment rinsate, transfer, and transport blank results were examined for values that exceeded the measurement quality objectives (MQO) criteria for each monitored analyte. If multiple types of blanks were collected during a water year, priority for evaluation was given to equipment blanks since it is the most inclusive and would be expected to be the most conservative of the three blank types. Ecology's 2007 stormwater permit's Appendix 9 Laboratory Methods targeted reporting limits were utilized when comparing blank analyte results to the applicable QAPPs MQO of twice the method reporting limit.

To address possible bias, some of the HDR site's respective stormwater data results and / or data qualifiers were changed during the water years the blanks were collected (Table 6) according to procedures in the revised 2011 QAPPs. Of the 9 pesticides and 4 nutrients monitored for 35 months during the project, only water year 2012's nitrate-nitrite as N and total phosphorus were deemed as needing revisions based on potential bias. Nitrate-nitrite as N did not require any revised results but did have slightly more than half (55%) of its un-flagged WY 2012 results' qualifiers revised to estimated "J's". Total phosphorus had two result values revised (18% of all their WY 2012 results had their method detection limits effectively raised to 0.068 mg/L) along with adding estimated qualifiers to the rest (82%) of the WY 2012 results. During water year 2013, the only S8E HDR parameter that had a significant blank hit was for the herbicide triclopyr (Garlon). However, the single high equipment blank value of 1.14 was substantially higher (at least three times greater) than any of the other seven routine or two other replicate WY 2012 results. Therefore, it was determined that this 1.14 value was an anomaly and was not utilized for revising or qualifying other triclopyr results. Corrective actions focused on review of procedures to minimize potential sources of contamination as much as practical.

The sediment sample collection bottle equipment blank results had nondetect results for all four pesticides (with lab method reporting limits of 0.21 ug/L for diazinon, chlorpyrifos, and malathion and 0.5 ug/L for pentachlorophenol). This suggests no obvious contamination sources for the sediment sample collection bottles and no need to revise sediment results due to bias.

**Table 6 WY2011-WY2013 QC multi-project blank samples resulting in revisions to applicable S8E HDR pesticide or nutrient monitoring results**

| Applicable Analyte (Units) | Permits' Targeted Reporting Limit | Applicable Water Year | Applicable QA / QC Blank Type & Result | Number of Data Results Revised (i.e. raised reported MDL) | Number of HDR Sample Qualifiers Revised to "J" Estimates |
|---|---|---|---|---|---|
| Nitrate-Nitrite as N (mg/L) | 0.01 | 2012 | Transport 0.042 | 0 of 11 (0%) | 6 of 11 (55%) |
| Total Phosphorus (mg/L) | 0.01 | 2012 | Transfer 0.068 | 2 of 11 (18%) | 9 of 11 (82%) |

Precision, as a measure of variability between original and replicate pairs of values, was evaluated for all applicable laboratory split composite samples as described in the project QAPP and Ecology's "Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies" (Ecology, 2004, pp. G1-G2). Similar to the approach used for bias, precision was evaluated using all pairs of duplicate composite results from all available concurrent and similar county monitoring projects (S8D Stormwater Characterization and S8F Best Management Practices Monitoring). Combining analyses of similarly sampled monitoring projects' duplicate results allowed the estimation of the pooled standard deviation across them and likely provides a better estimate of the overall precision. However, precision as measured by the pooled relative standard deviation (RSD) or relative percent differences (RPD) within individual pairs of duplicates was not evaluated for results at or below method detection limits because of the inherent higher variability at these very low values.

Some stormwater parameters' precision calculations were divided into lower and higher concentration groups when the range of their results exceeded an order of magnitude (Table 7). For all the S8E HDR's monitored parameters, both the RSD's and RPD's generally compared favorably with the QAPP's measurement quality objective criteria of 25% for precision. Only the RSD value of 68% for ortho-phosphate's upper concentration group exceeded the criterion. Similarly, only a small minority (14% and 20%) of the individual duplicate pairs' RPD's in each analyzed period was large enough to exceed the criterion. Therefore, per the QAPP, applicable orthophosphate results were flagged with estimate "J's".

**Table 7 WY2011-2013 Precision summary based on multi-project QC split stormwater samples resulting in revisions to applicable S8E HDR pesticide or nutrient monitoring results qualifiers**

| Applicable Period and Analyte (Units) | Number of Paired Duplicates | Pooled Standard Deviation | Relative Standard Deviation Using Pooled SD (%) | Highest Duplicate Pair Relative Percent Difference [RPD] (%) | # of Applicable Duplicate Pairs that Exceed RPD MQO of 25% ~ | Number (%) of Routine HDR Results Qualifiers Revised to "J" |
|---|---|---|---|---|---|---|
| 10/30/11-3/1/12 Ortho-phosphorus as P [low concs.] (mg P/L) | 7 | 0.003 | 18% | 34% | 1 of 7 (14%) | 7 of 7 (100%) |
| 11/17/12-1/23/13 Ortho-phosphorus as P [high concs.] (mg P/L) | 2 | 0.12 | 68% | 96% | 1 of 5 (20%) | 2 of 2 (100%) |

~ Not all duplicate pairs justified revising data qualifiers (non-detect values are inherently variable or other concurrent replicates met precision measurement quality objectives).

Evaluation of this project's HDR sediment sample precision was based on original and duplicate sediment samples for the S8D project's LDR May 20, 2013 sediment results. Evaluation of precision for the four S8E sediment pesticide parameters sampled is limited to the single original / duplicate pair of pentachlorophenol results which was the only sediment pesticide that had values above its detection limits. The calculated relative percent difference (RPD) for this data pair of 13% met the project's measurement quality objective of 25%. Therefore, this S8E project's sediment results precision is acceptable.

## Data Review, Verification, and Validation

Procedures described in the project QAPP were followed for data review, verification, and validation. Field sheets and chain of custody documents were reviewed by the project manager for accuracy and completeness. Field sheet corrections are noted and initialed. All laboratory data are reviewed shortly after receipt of electronic reports for obvious omissions or errors. The ALS Environmental Lab in Kelso, Washington is notified of omissions or errors as soon as possible so that re-analyses can occur if holding times allow. Laboratory corrections or missing data are then sent to Clark County as revised reports. Electronic data (EDD) files are uploaded into Clark County's Water Quality Database (WQDB) for subsequent detailed review. Missing or erroneous digital data were then reviewed in more detail, evaluated, and as applicable replaced, qualified, or rejected.

All monitoring results were verified and validated based on the criteria for measurement quality objectives included in the project's QAPP. As part of the bias analyses and summarized in Table 6, comparisons of blank QC sample results and routine sample results led to some changes of analyte results and data qualifiers in the WQDB. As described above, precision evaluation results are summarized in Table 7. The laboratory analyses internal precision was maintained by the lab (as well as data verification and validation), with exceptions noted in their individual sample reports to the County, but overall was deemed acceptable. The accuracy of the hydrology measurements is assumed acceptable based on following generally accepted standard operation procedures and professional judgment. As noted above, sensitivity requirements were generally met by the laboratory achieving reporting limits for the vast majority of analyses except as noted in their individual sample reports and subsequent flagging of data results. The project's measurement quality objective for completeness was fulfilled by collecting and analyzing a sufficient number of before (20) and after (11) education period samples at the HDR monitoring station with sufficient volume for laboratory analysis of all listed parameters. Hydrology measurements were deemed completed by monitoring the vast majority of the targeted events. Representativeness objectives were generally met by following approved analytical and field methods, usually meeting holding times (exceptions noted in lab reports), sampling only events meeting criteria, and usually capturing at least ten aliquots over 6 to 24 hours on the targeted storm event.

## Data Quality Assessment

Overall, the analytical and hydrology monitoring results package for the S8E stormwater monitoring project using the high density residential site's results are considered acceptable, usable (based on measurement quality objectives), and achieving the project's main monitoring goals and objectives. This monitoring effort met the data quality assessment's main goals for completeness, representativeness of the HDR stormwater drainage, and being reasonably sufficient to evaluate differences in stormwater nutrient and pesticides levels for the before and after S8E education campaign given limited available project resources.

# Conclusions

Overall, this study showed that monitored stormwater nutrient concentrations were generally relatively low and pesticide concentrations were especially low for the high density residential monitoring site. Medians of monitored stormwater nutrients at the HDR site were lower than (ranging from 12% to 89% of) those reported from residential land use in the national Stormwater Quality Database (NSQD). In fact, most HDR pesticide results were below the laboratory's most sensitive reported detection limits.

Statistical testing required focusing on a subset of HDR's entire monitoring results. The evaluation period was narrowed to after 2010 to reduce potential confounding impacts on analyses from less sensitive early laboratory analyses. Additionally, only monitored parameters with more than 30% of their results being detected were utilized to reliably calculate summary statistics and perform statistical tests. In addition to using robust nonparametric statistics, graphical exploratory analyses provided insights into the practicality of statistically significant differences between pre- and post- education period results.

The study area's education campaign may have resulted in some environmental benefits from residents' behavior changes, but this study cannot reliably say detected significant stormwater quality improvements result from just the education campaign. While the only statistically significant pesticide reduction was for the herbicide dichlobenil, it's not possible to specifically link it to the education campaign due to other potential causes. Also, the significant reductions found by this study in the nutrients nitrate-nitrite and increases in total phosphorus concentrations or loads are not of practical significance and could be due to a wide range of causes unrelated to the education campaign. However, in Puget Sound, it has been found that awareness of stormwater pollution issues using similar focused education campaigns may be a prerequisite for successful behavior change that can ultimately reduce pollutants (Leska, 2013, p. 3).

While feasibility of analyses was not a specific objective of this environmental outcome study, it was found to be infeasible to statistically evaluate the effectiveness of the education campaign via improvements in most pesticide concentrations. This was primarily due to the very high proportions of nondetect results for most pesticides that reduced the reliability of statistical comparisons. Additionally, given the high proportion of censored pesticide results, it seems unlikely different conclusions could be drawn even if an alternative, more elaborate monitoring design was utilized.

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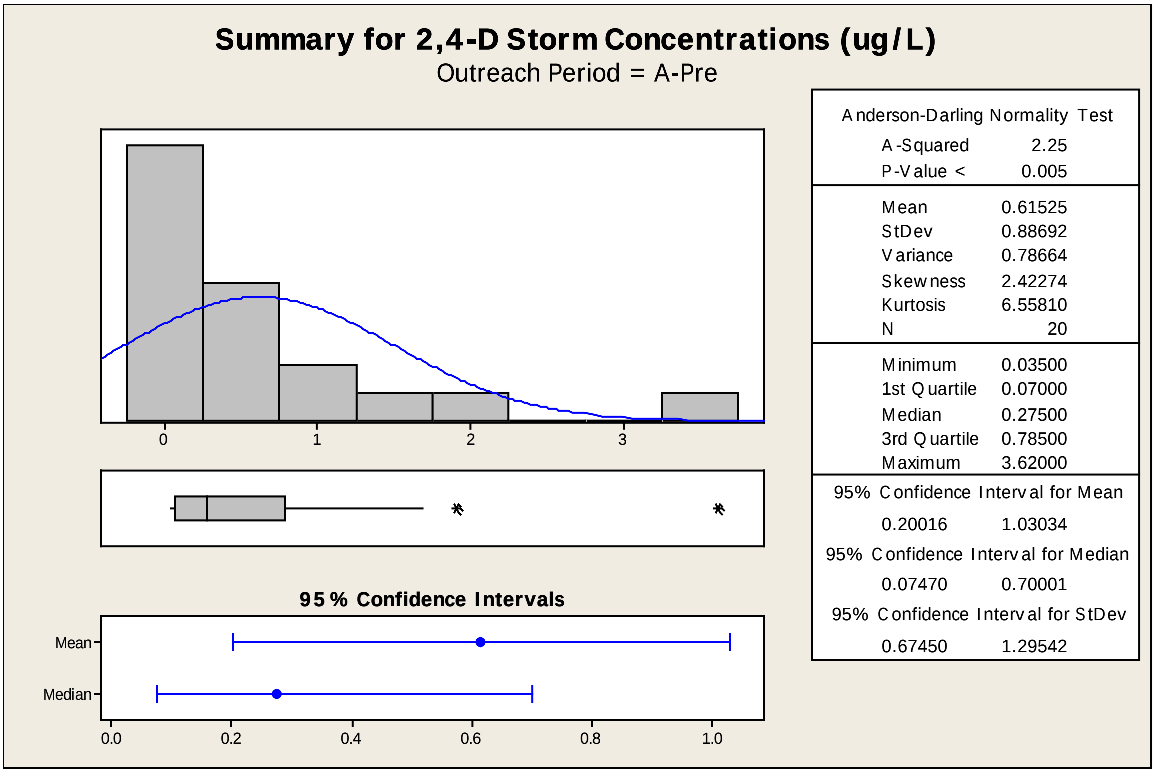
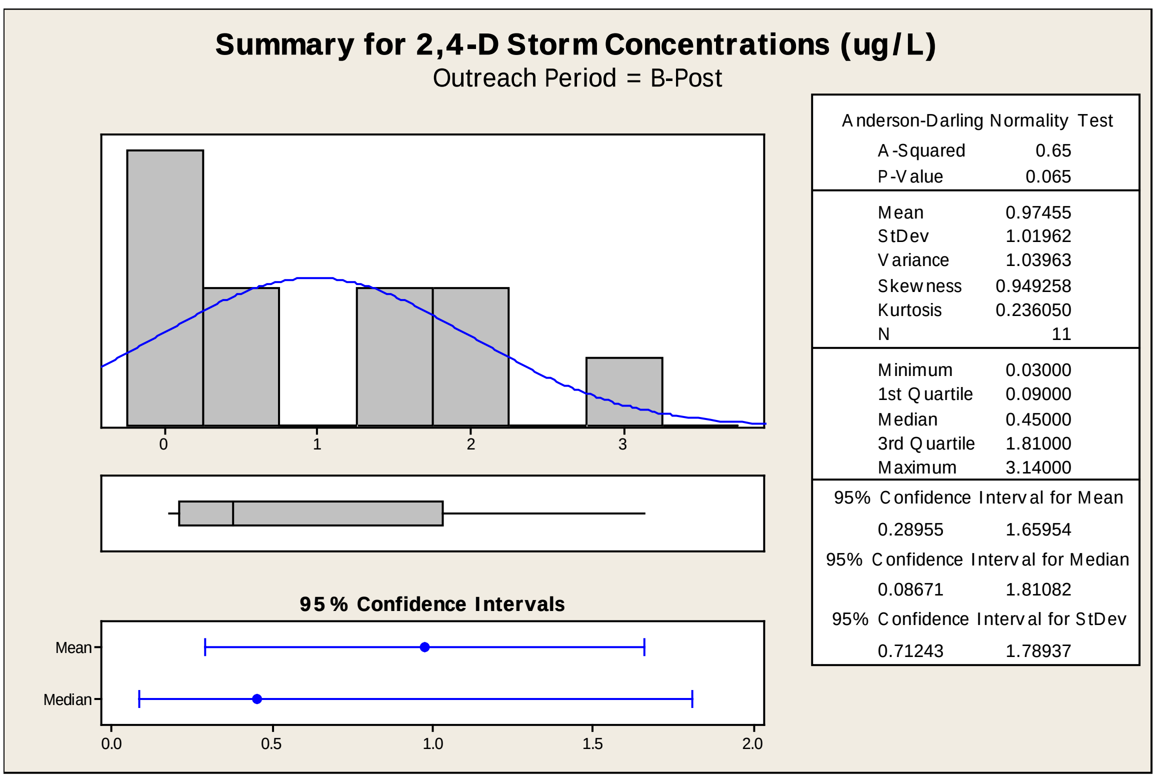
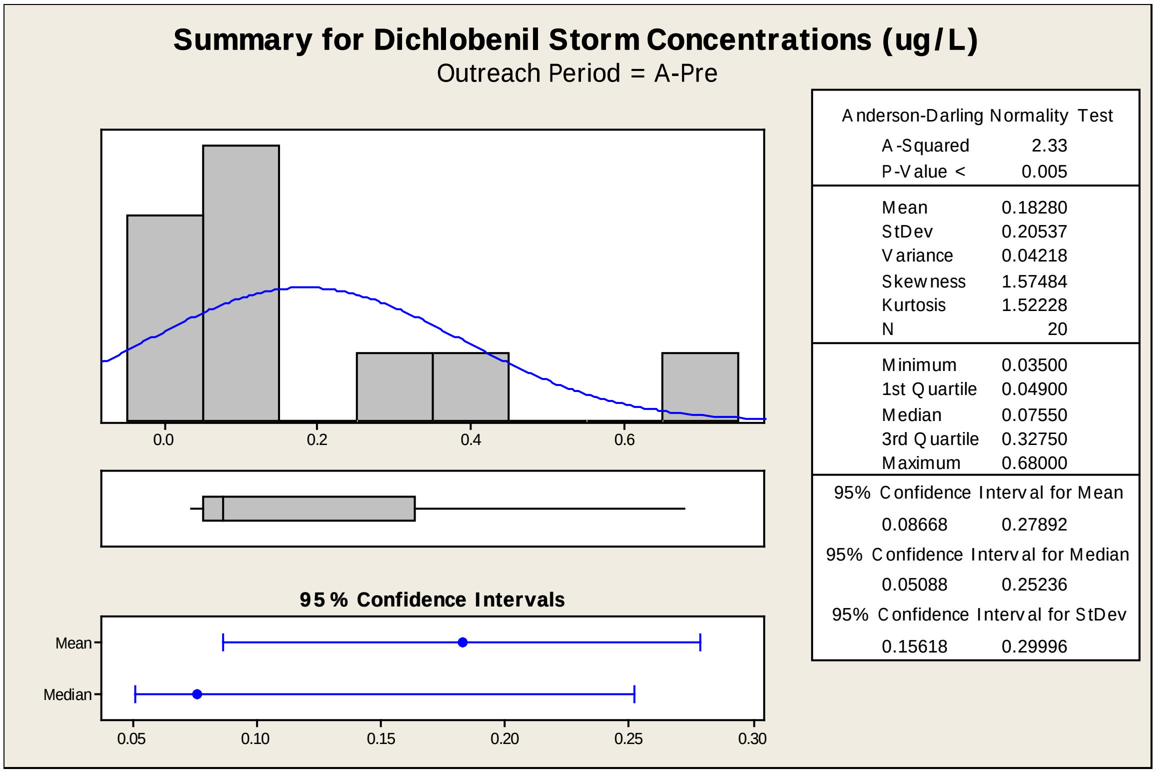
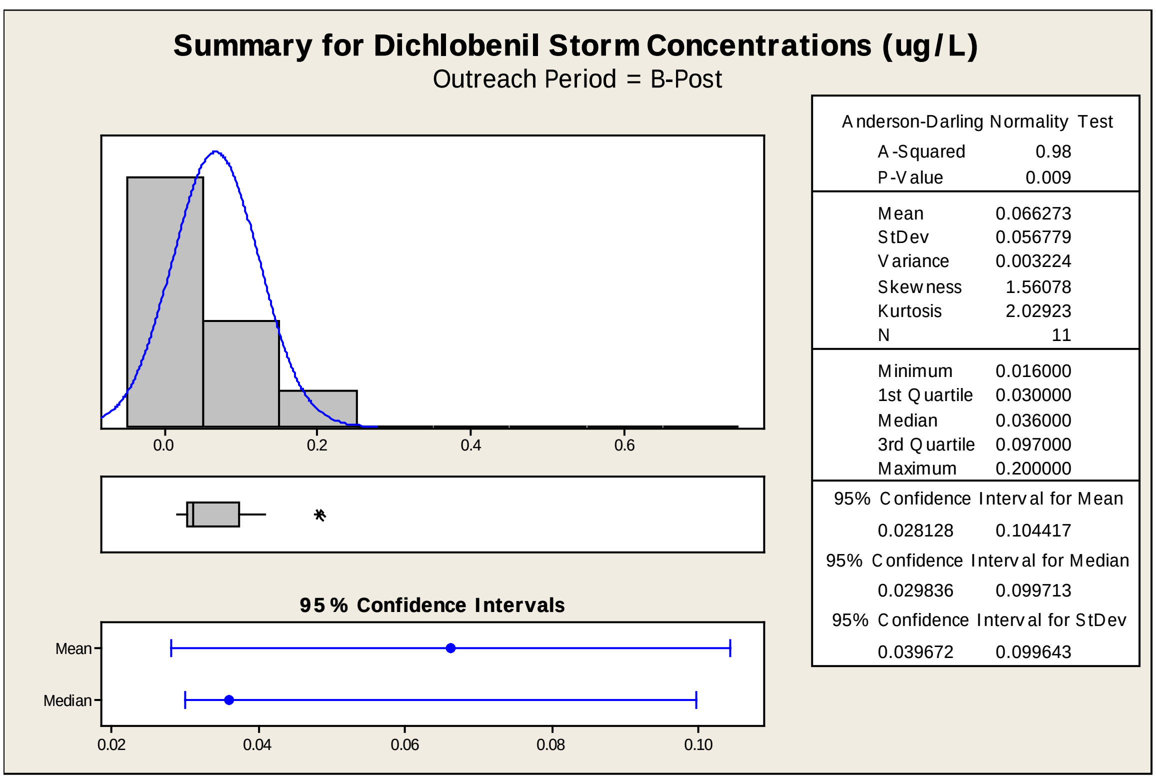
# Appendices

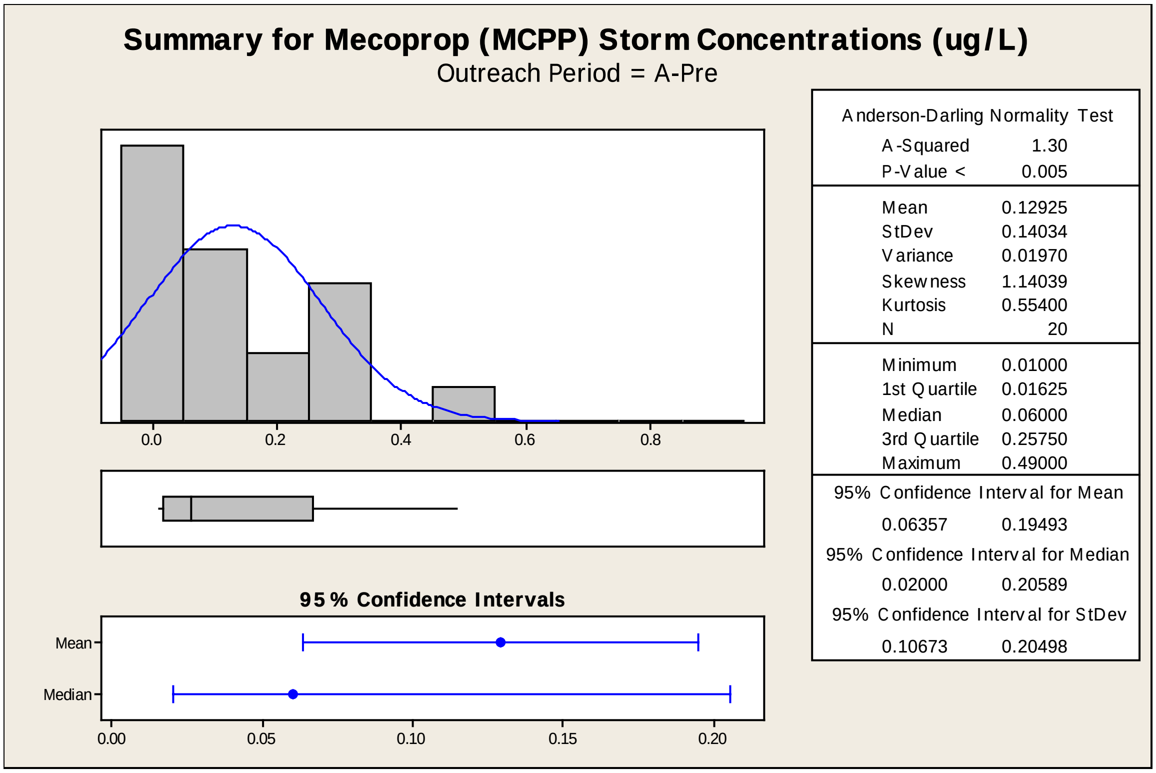
## Appendix 1A  Pre- and Post- Education Storm Concentrations Summary Statistics

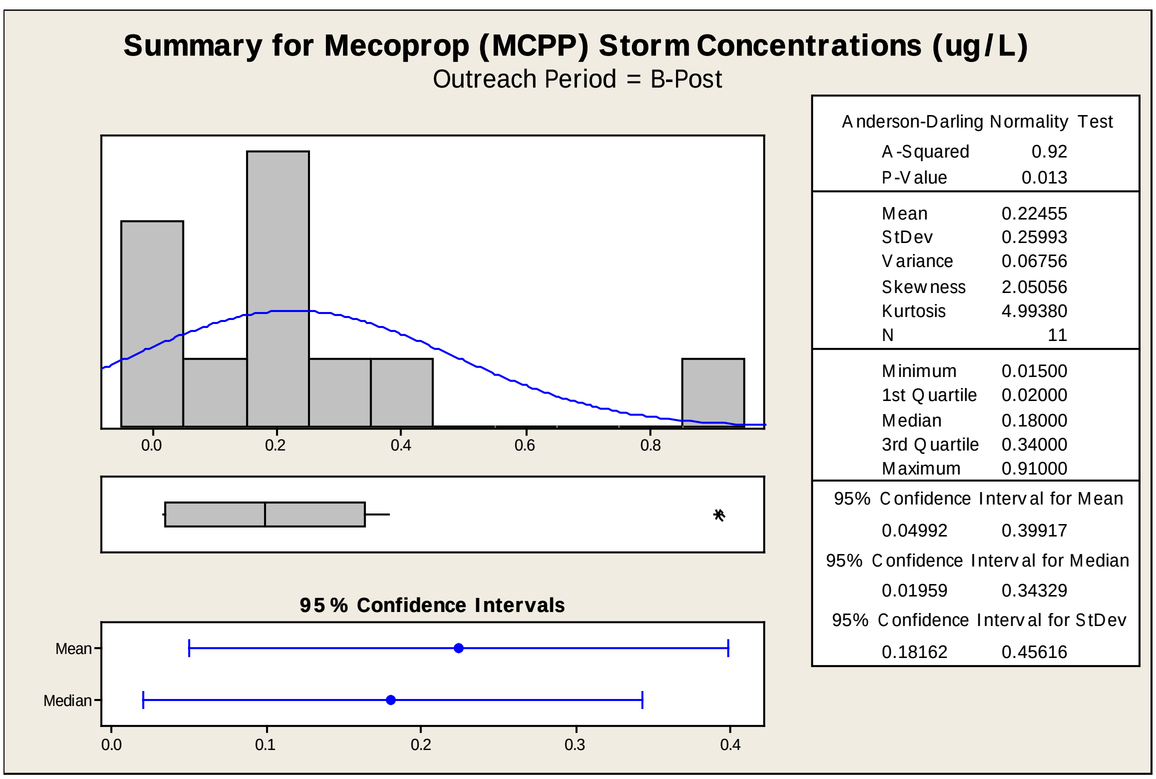

Summary for 2,4-D Storm Concentrations (ug/L)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 2.25
P-Value < 0.005
Mean 0.61525
StDev 0.88692
Variance 0.78664
Skewness 2.42274
Kurtosis 6.55810
N 20
Minimum 0.03500
1st Quartile 0.07000
Median 0.27500
3rd Quartile 0.78500
Maximum 3.62000
95% Confidence Interval for Mean
0.20016 1.03034
95% Confidence Interval for Median
0.07470 0.70001
95% Confidence Interval for StDev
0.67450 1.29542
0 1 2 3
95% Confidence Intervals
Mean
Median
0.0 0.2 0.4 0.6 0.8 1.0

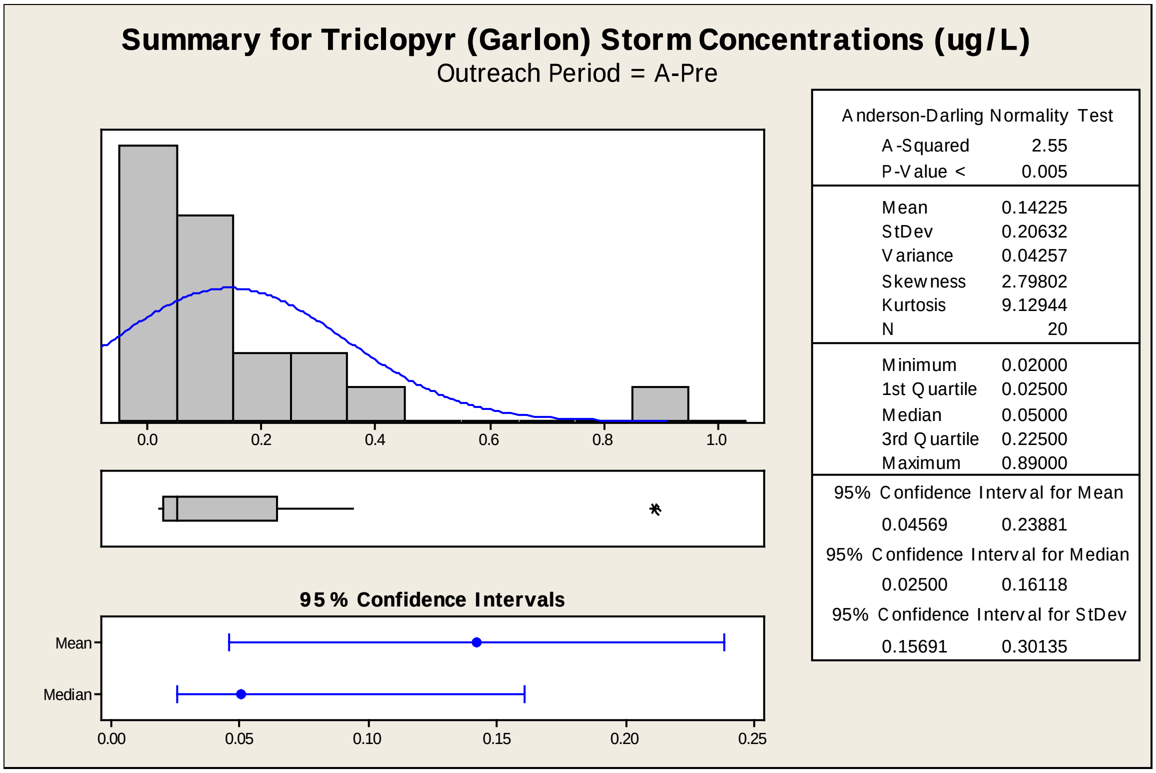

Summary for 2,4-D Storm Concentrations (ug/L)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.65
P-Value 0.065
Mean 0.97455
StDev 1.01962
Variance 1.03963
Skewness 0.949258
Kurtosis 0.236050
N 11
Minimum 0.03000
1st Quartile 0.09000
Median 0.45000
3rd Quartile 1.81000
Maximum 3.14000
95% Confidence Interval for Mean
0.28955 1.65954
95% Confidence Interval for Median
0.08671 1.81082
95% Confidence Interval for StDev
0.71243 1.78937
0 1 2 3
95% Confidence Intervals
Mean
Median
0.0 0.5 1.0 1.5 2.0

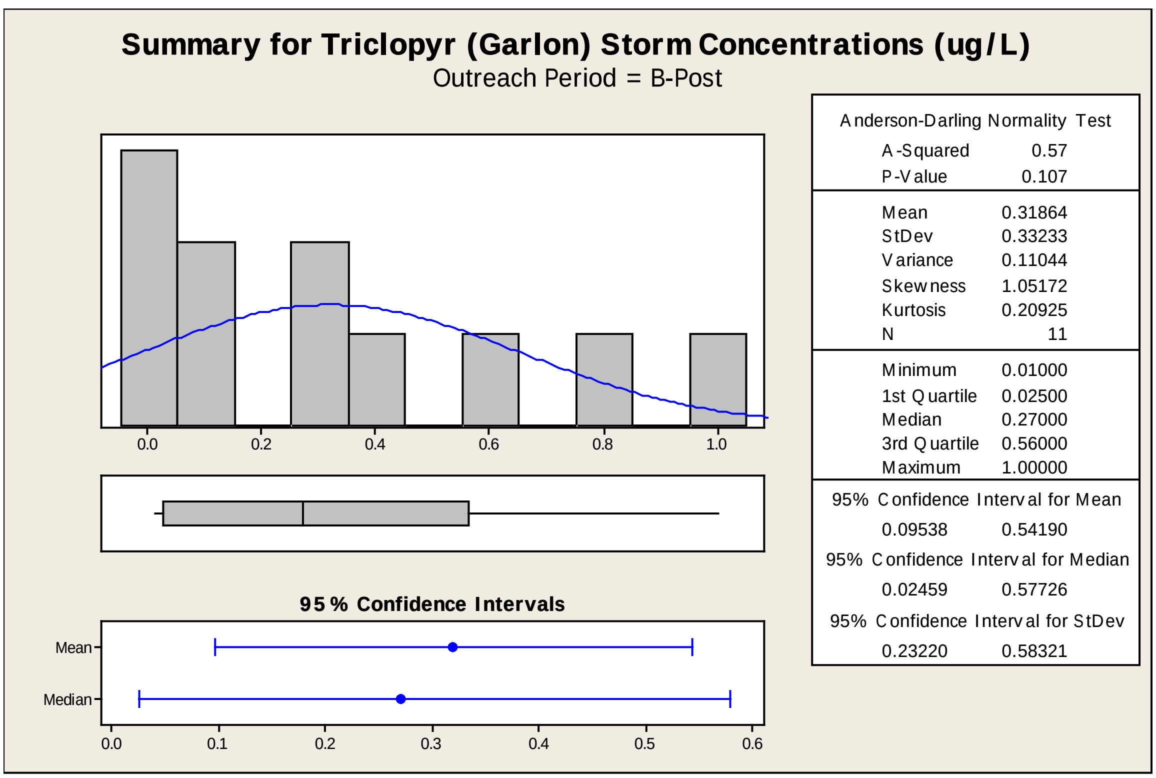

Summary for Dichlobenil Storm Concentrations (ug/L)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 2.33
P-Value < 0.005
Mean 0.18280
StDev 0.20537
Variance 0.04218
Skewness 1.57484
Kurtosis 1.52228
N 20
Minimum 0.03500
1st Quartile 0.04900
Median 0.07550
3rd Quartile 0.32750
Maximum 0.68000
95% Confidence Interval for Mean
0.08668 0.27892
95% Confidence Interval for Median
0.05088 0.25236
95% Confidence Interval for StDev
0.15618 0.29996
0.0
0.2
0.4
0.6
95% Confidence Intervals
Mean
Median
0.05
0.10
0.15
0.20
0.25
0.30

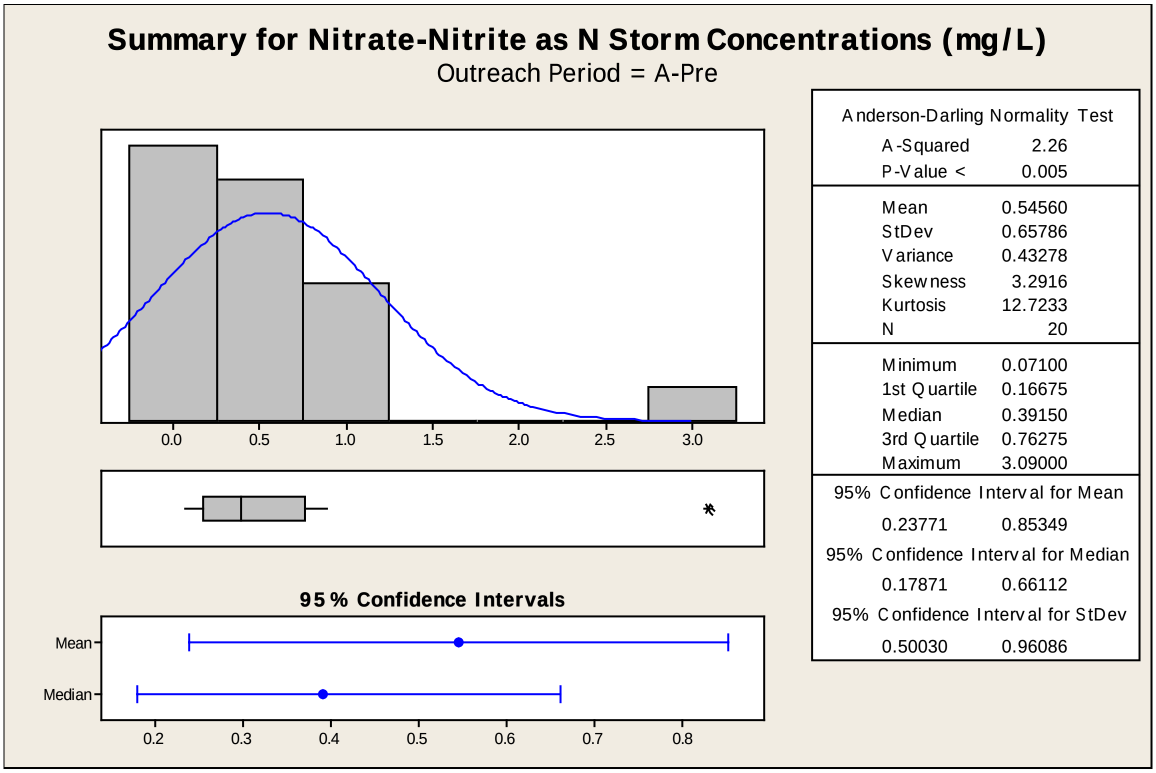

Summary for Dichlobenil Storm Concentrations (ug/L)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.98
P-Value 0.009
Mean 0.066273
StDev 0.056779
Variance 0.003224
Skewness 1.56078
Kurtosis 2.02923
N 11
Minimum 0.016000
1st Quartile 0.030000
Median 0.036000
3rd Quartile 0.097000
Maximum 0.200000
95% Confidence Interval for Mean
0.028128 0.104417
95% Confidence Interval for Median
0.029836 0.099713
95% Confidence Interval for StDev
0.039672 0.099643
0.0
0.2
0.4
0.6
95% Confidence Intervals
Mean
Median
0.02
0.04
0.06
0.08
0.10

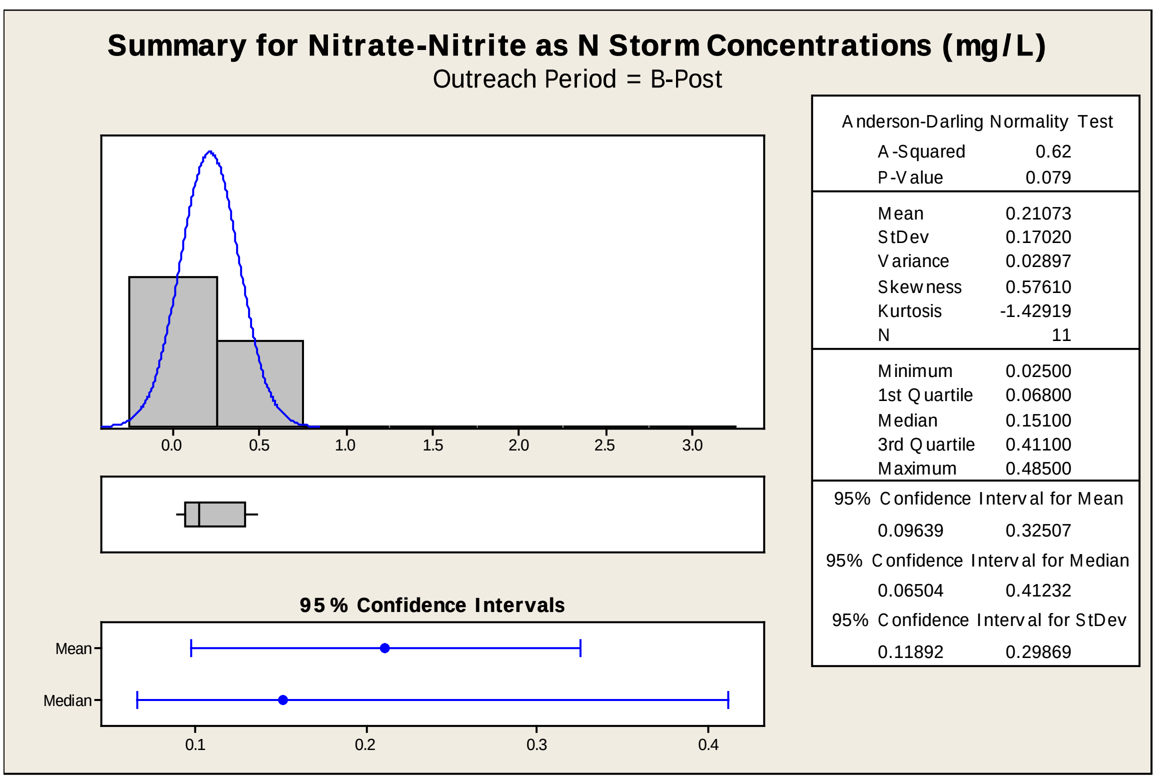

Summary for Mecoprop (MCPP) Storm Concentrations (ug/L)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 1.30
P-Value < 0.005
Mean 0.12925
StDev 0.14034
Variance 0.01970
Skewness 1.14039
Kurtosis 0.55400
N 20
Minimum 0.01000
1st Quartile 0.01625
Median 0.06000
3rd Quartile 0.25750
Maximum 0.49000
95% Confidence Interval for Mean
0.06357 0.19493
95% Confidence Interval for Median
0.02000 0.20589
95% Confidence Interval for StDev
0.10673 0.20498
0.0
0.2
0.4
0.6
0.8
95% Confidence Intervals
Mean
Median
0.00
0.05
0.10
0.15
0.20

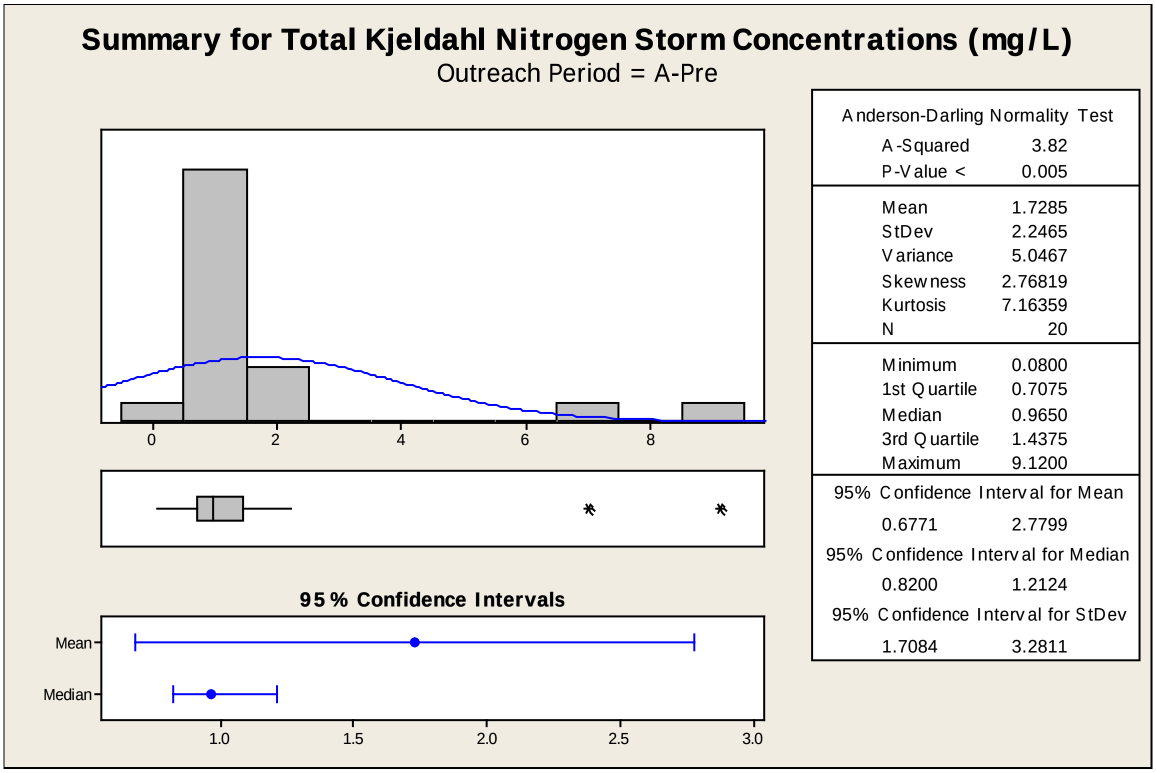

Summary for Mecoprop (MCPP) Storm Concentrations (ug/L)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.92
P-Value 0.013
Mean 0.22455
StDev 0.25993
Variance 0.06756
Skewness 2.05056
Kurtosis 4.99380
N 11
Minimum 0.01500
1st Quartile 0.02000
Median 0.18000
3rd Quartile 0.34000
Maximum 0.91000
95% Confidence Interval for Mean
0.04992 0.39917
95% Confidence Interval for Median
0.01959 0.34329
95% Confidence Interval for StDev
0.18162 0.45616
0.0
0.2
0.4
0.6
0.8
95% Confidence Intervals
Mean
Median
0.0
0.1
0.2
0.3
0.4

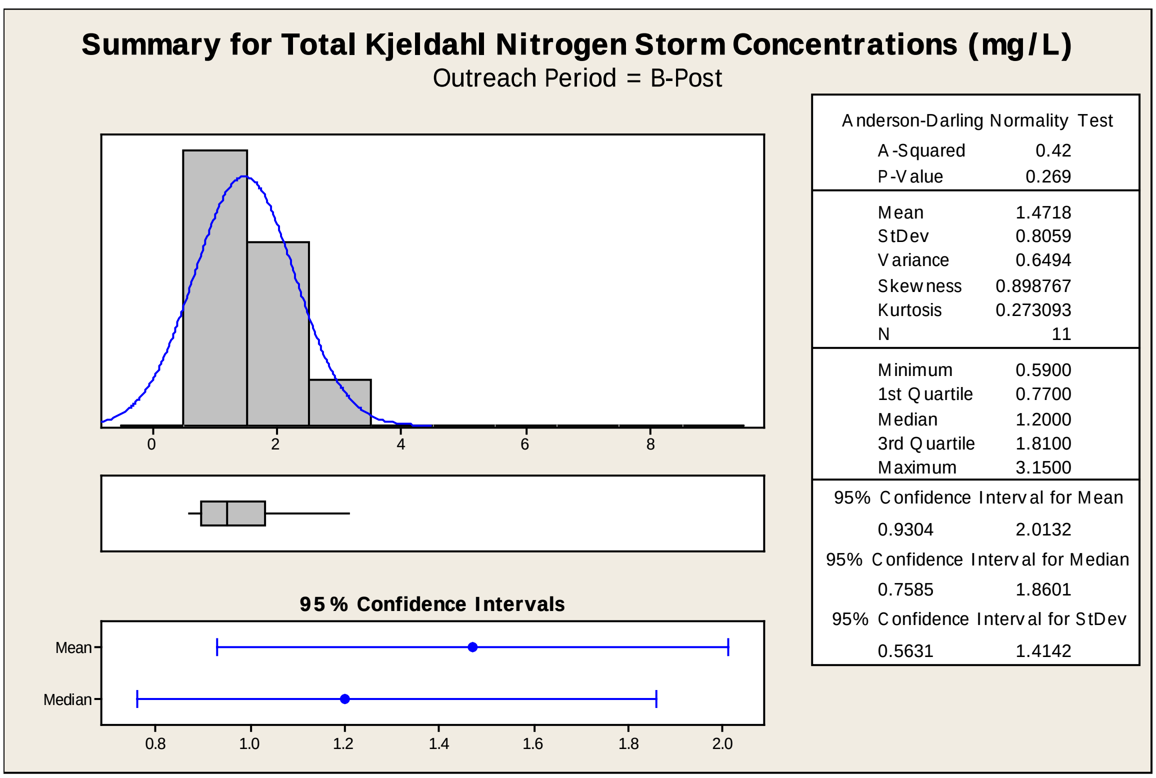

Summary for Triclopyr (Garlon) Storm Concentrations (ug/L)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 2.55
P-Value < 0.005
Mean 0.14225
StDev 0.20632
Variance 0.04257
Skewness 2.79802
Kurtosis 9.12944
N 20
Minimum 0.02000
1st Quartile 0.02500
Median 0.05000
3rd Quartile 0.22500
Maximum 0.89000
95% Confidence Interval for Mean
0.04569 0.23881
95% Confidence Interval for Median
0.02500 0.16118
95% Confidence Interval for StDev
0.15691 0.30135
0.0 0.2 0.4 0.6 0.8 1.0
95% Confidence Intervals
Mean
Median
0.00 0.05 0.10 0.15 0.20 0.25

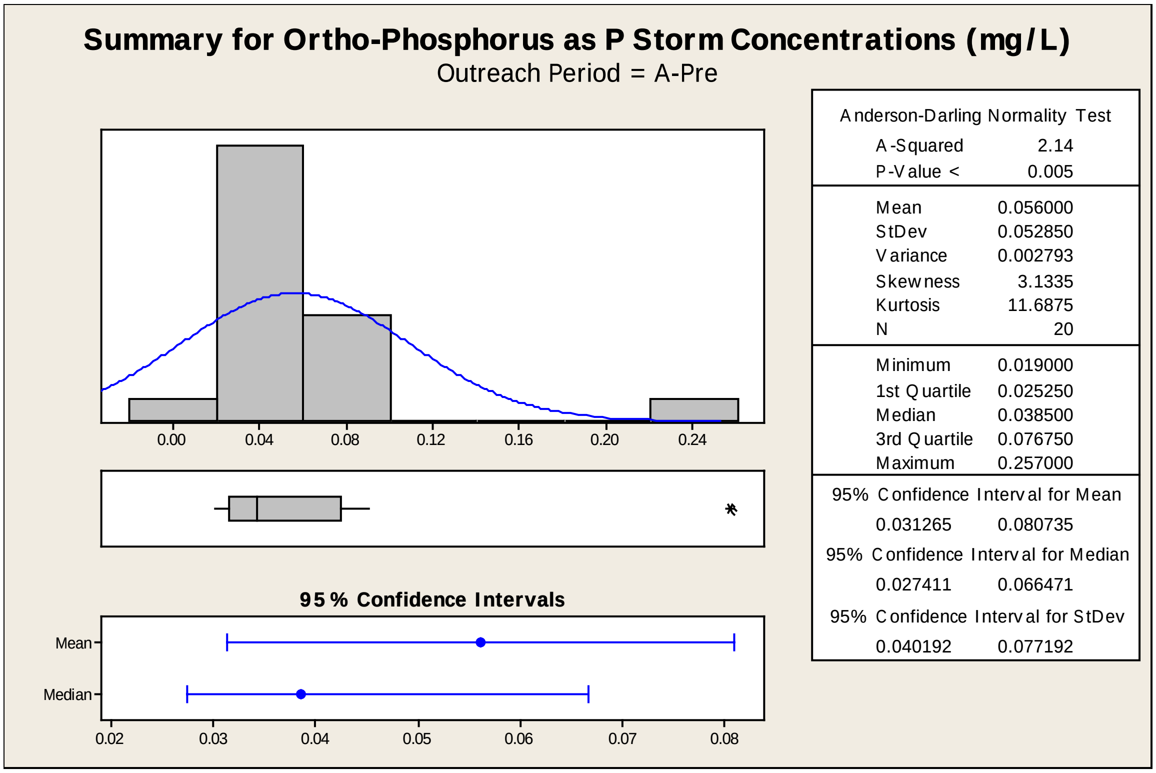

Summary for Triclopyr (Garlon) Storm Concentrations (ug/L)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.57
P-Value 0.107
Mean 0.31864
StDev 0.33233
Variance 0.11044
Skewness 1.05172
Kurtosis 0.20925
N 11
Minimum 0.01000
1st Quartile 0.02500
Median 0.27000
3rd Quartile 0.56000
Maximum 1.00000
95% Confidence Interval for Mean
0.09538 0.54190
95% Confidence Interval for Median
0.02459 0.57726
95% Confidence Interval for StDev
0.23220 0.58321
0.0 0.2 0.4 0.6 0.8 1.0
95% Confidence Intervals
Mean
Median
0.0 0.1 0.2 0.3 0.4 0.5 0.6

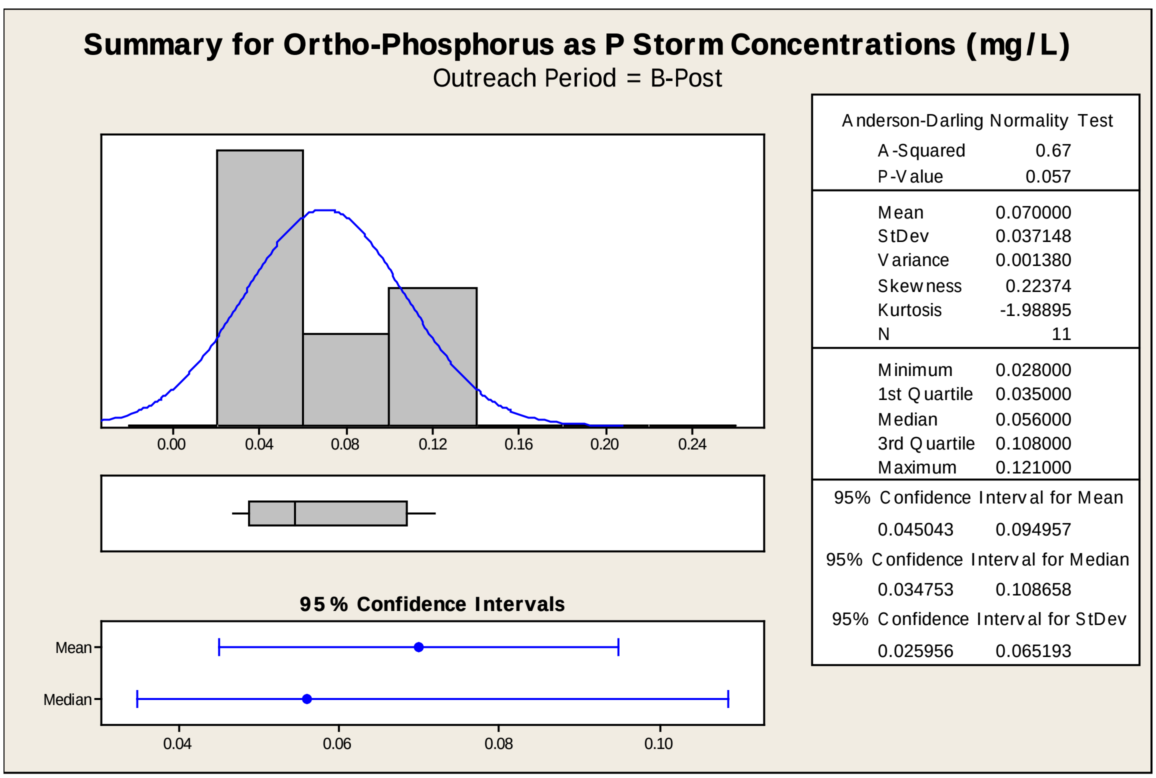

Summary for Nitrate-Nitrite as N Storm Concentrations (mg/L)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 2.26
P-Value < 0.005
Mean 0.54560
StDev 0.65786
Variance 0.43278
Skewness 3.2916
Kurtosis 12.7233
N 20
Minimum 0.07100
1st Quartile 0.16675
Median 0.39150
3rd Quartile 0.76275
Maximum 3.09000
95% Confidence Interval for Mean
0.23771 0.85349
95% Confidence Interval for Median
0.17871 0.66112
95% Confidence Interval for StDev
0.50030 0.96086
0.0 0.5 1.0 1.5 2.0 2.5 3.0
95% Confidence Intervals
Mean
Median
0.2 0.3 0.4 0.5 0.6 0.7 0.8

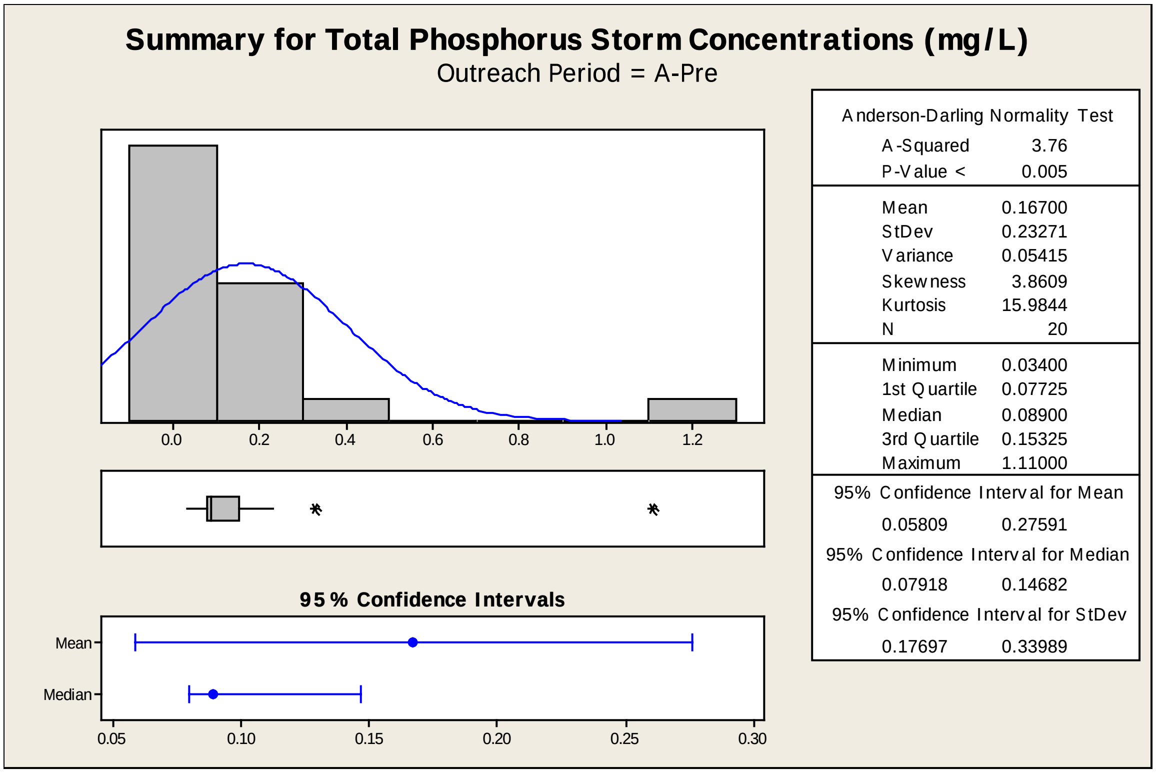

Summary for Nitrate-Nitrite as N Storm Concentrations (mg/L)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.62
P-Value 0.079
Mean 0.21073
StDev 0.17020
Variance 0.02897
Skewness 0.57610
Kurtosis -1.42919
N 11
Minimum 0.02500
1st Quartile 0.06800
Median 0.15100
3rd Quartile 0.41100
Maximum 0.48500
95% Confidence Interval for Mean
0.09639 0.32507
95% Confidence Interval for Median
0.06504 0.41232
95% Confidence Interval for StDev
0.11892 0.29869
0.0 0.5 1.0 1.5 2.0 2.5 3.0
95% Confidence Intervals
Mean
Median
0.1 0.2 0.3 0.4

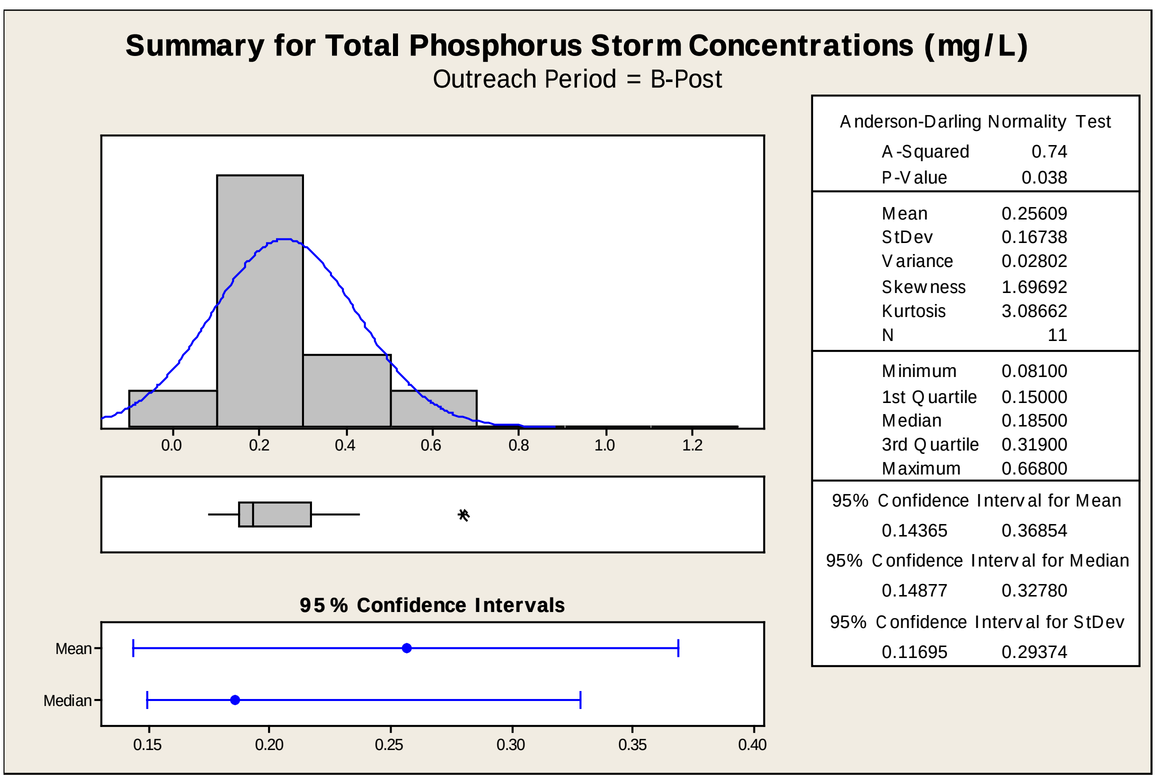

Summary for Total Kjeldahl Nitrogen Storm Concentrations (mg/L)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 3.82
P-Value < 0.005
Mean 1.7285
StDev 2.2465
Variance 5.0467
Skewness 2.76819
Kurtosis 7.16359
N 20
Minimum 0.0800
1st Quartile 0.7075
Median 0.9650
3rd Quartile 1.4375
Maximum 9.1200
95% Confidence Interval for Mean
0.6771 2.7799
95% Confidence Interval for Median
0.8200 1.2124
95% Confidence Interval for StDev
1.7084 3.2811
0
2
4
6
8
95% Confidence Intervals
Mean
Median
1.0
1.5
2.0
2.5
3.0


Summary for Total Kjeldahl Nitrogen Storm Concentrations (mg/L)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.42
P-Value 0.269
Mean 1.4718
StDev 0.8059
Variance 0.6494
Skewness 0.898767
Kurtosis 0.273093
N 11
Minimum 0.5900
1st Quartile 0.7700
Median 1.2000
3rd Quartile 1.8100
Maximum 3.1500
95% Confidence Interval for Mean
0.9304 2.0132
95% Confidence Interval for Median
0.7585 1.8601
95% Confidence Interval for StDev
0.5631 1.4142
0
2
4
6
8
95% Confidence Intervals
Mean
Median
0.8
1.0
1.2
1.4
1.6
1.8
2.0

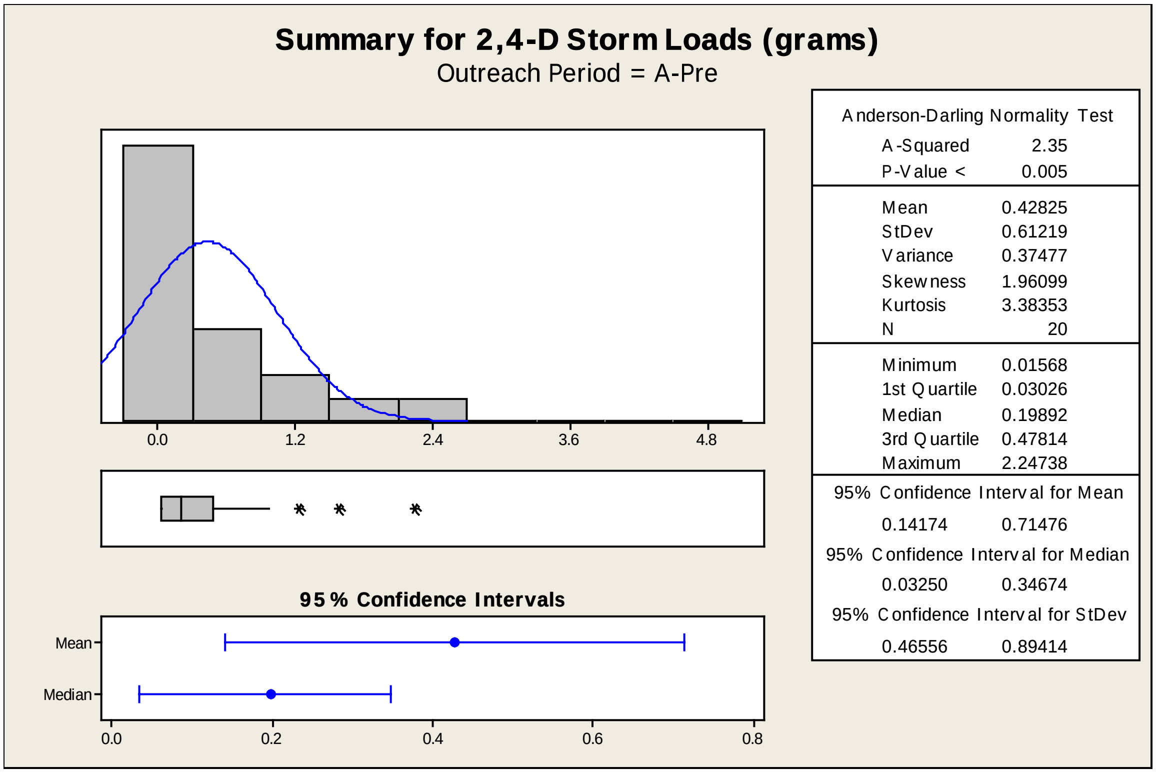

Summary for Ortho-Phosphorus as P Storm Concentrations (mg/L)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 2.14
P-Value < 0.005
Mean 0.056000
StDev 0.052850
Variance 0.002793
Skewness 3.1335
Kurtosis 11.6875
N 20
Minimum 0.019000
1st Quartile 0.025250
Median 0.038500
3rd Quartile 0.076750
Maximum 0.257000
95% Confidence Interval for Mean
0.031265 0.080735
95% Confidence Interval for Median
0.027411 0.066471
95% Confidence Interval for StDev
0.040192 0.077192
0.00 0.04 0.08 0.12 0.16 0.20 0.24
95% Confidence Intervals
Mean
Median
0.02 0.03 0.04 0.05 0.06 0.07 0.08

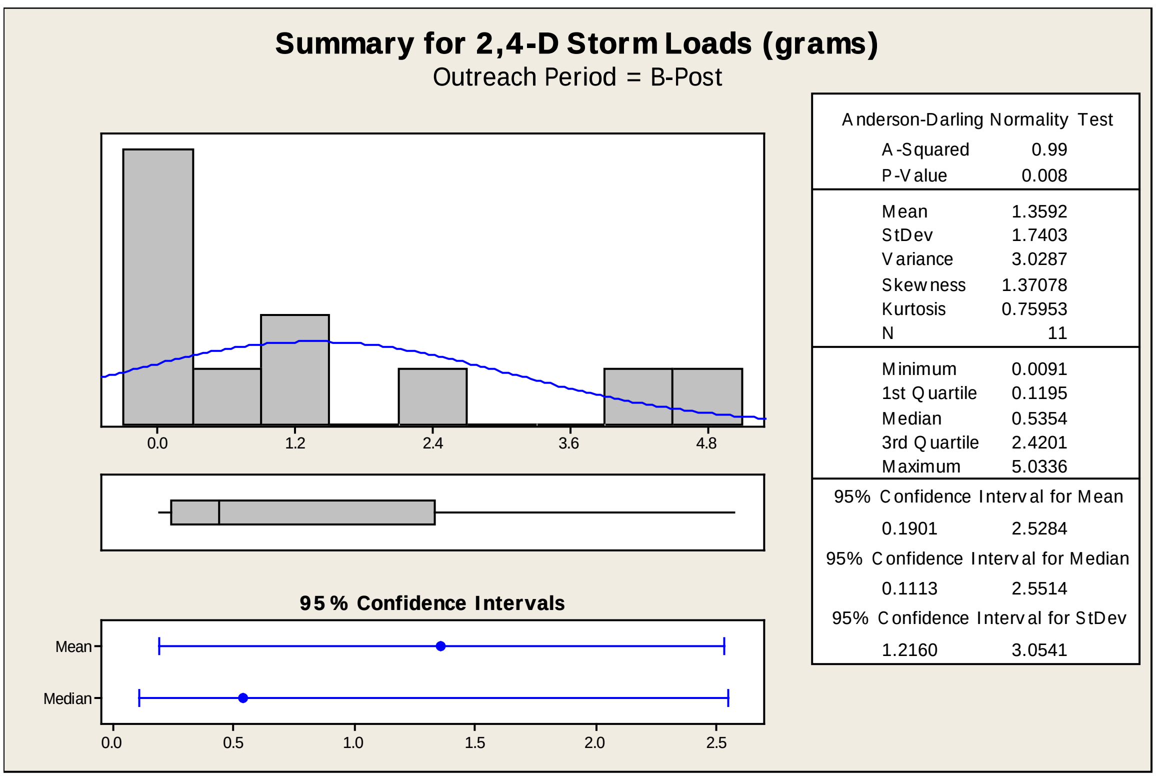

Summary for Ortho-Phosphorus as P Storm Concentrations (mg/L)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.67
P-Value 0.057
Mean 0.070000
StDev 0.037148
Variance 0.001380
Skewness 0.22374
Kurtosis -1.98895
N 11
Minimum 0.028000
1st Quartile 0.035000
Median 0.056000
3rd Quartile 0.108000
Maximum 0.121000
95% Confidence Interval for Mean
0.045043 0.094957
95% Confidence Interval for Median
0.034753 0.108658
95% Confidence Interval for StDev
0.025956 0.065193
0.00 0.04 0.08 0.12 0.16 0.20 0.24
95% Confidence Intervals
Mean
Median
0.04 0.06 0.08 0.10

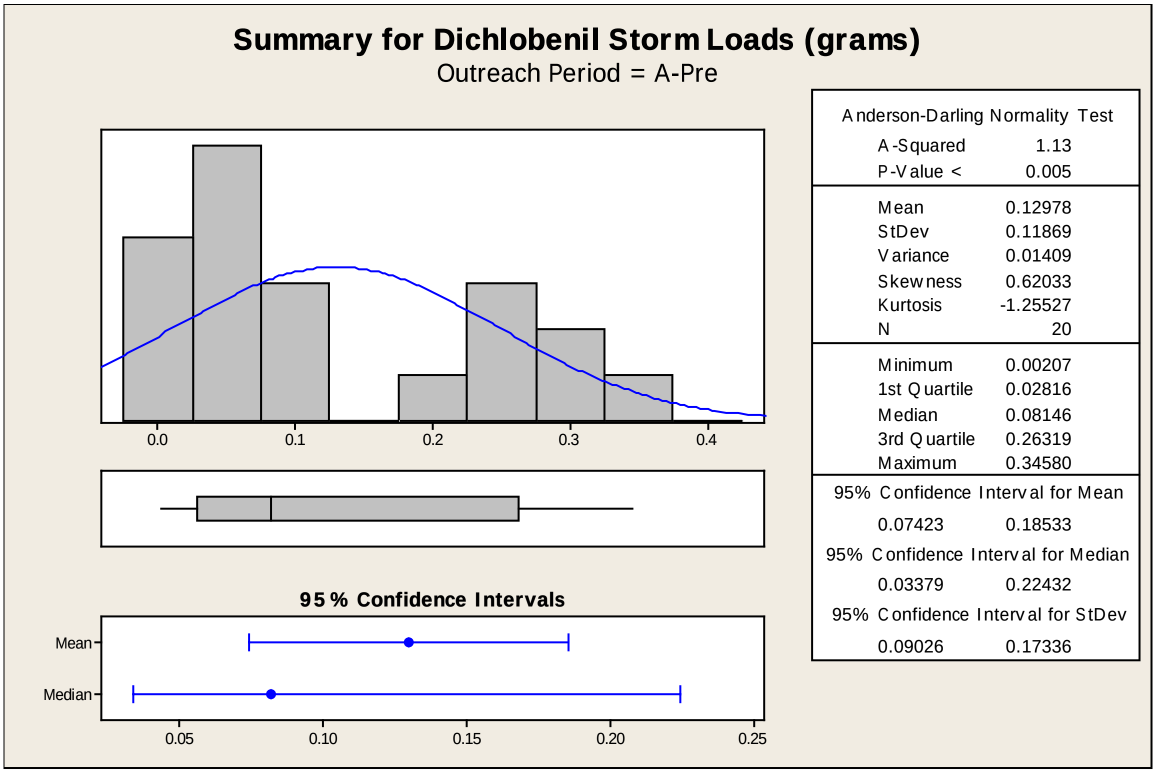

Summary for Total Phosphorus Storm Concentrations (mg/L)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 3.76
P-Value < 0.005
Mean 0.16700
StDev 0.23271
Variance 0.05415
Skewness 3.8609
Kurtosis 15.9844
N 20
Minimum 0.03400
1st Quartile 0.07725
Median 0.08900
3rd Quartile 0.15325
Maximum 1.11000
95% Confidence Interval for Mean
0.05809 0.27591
95% Confidence Interval for Median
0.07918 0.14682
95% Confidence Interval for StDev
0.17697 0.33989
0.0 0.2 0.4 0.6 0.8 1.0 1.2
95% Confidence Intervals
Mean
Median
0.05 0.10 0.15 0.20 0.25 0.30

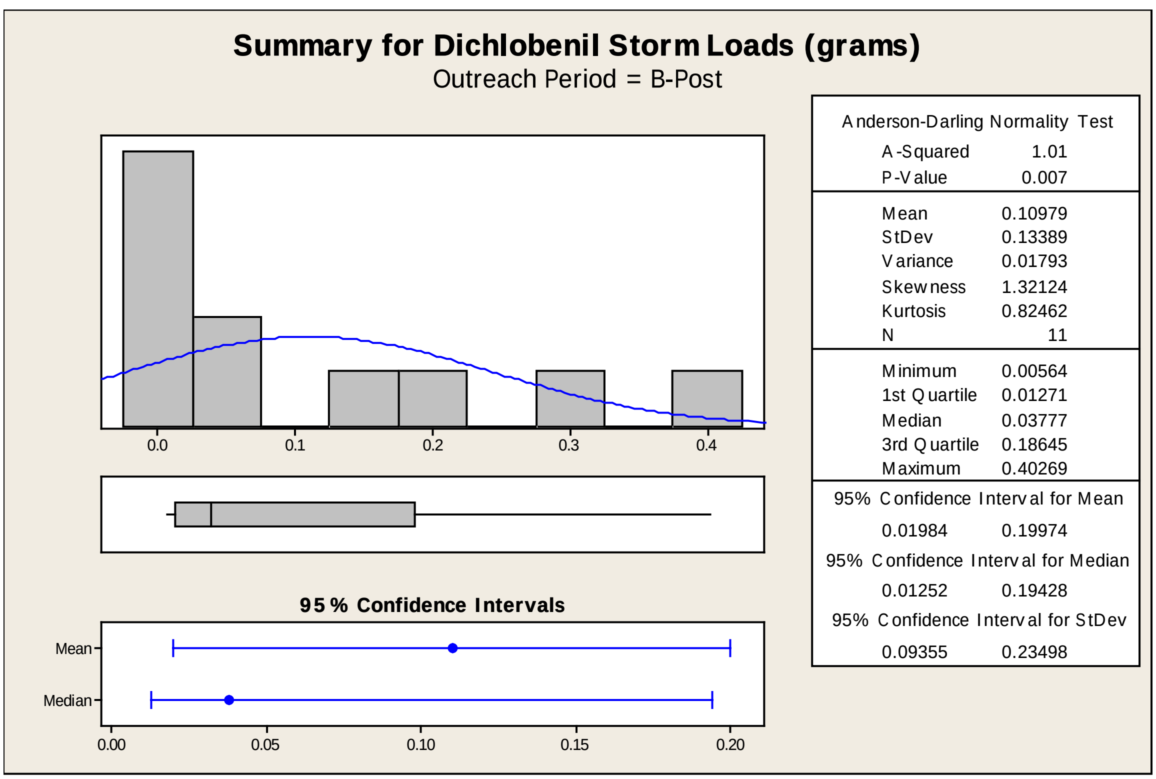

Summary for Total Phosphorus Storm Concentrations (mg/L)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.74
P-Value 0.038
Mean 0.25609
StDev 0.16738
Variance 0.02802
Skewness 1.69692
Kurtosis 3.08662
N 11
Minimum 0.08100
1st Quartile 0.15000
Median 0.18500
3rd Quartile 0.31900
Maximum 0.66800
95% Confidence Interval for Mean
0.14365 0.36854
95% Confidence Interval for Median
0.14877 0.32780
95% Confidence Interval for StDev
0.11695 0.29374
0.0 0.2 0.4 0.6 0.8 1.0 1.2
95% Confidence Intervals
Mean
Median
0.15 0.20 0.25 0.30 0.35 0.40

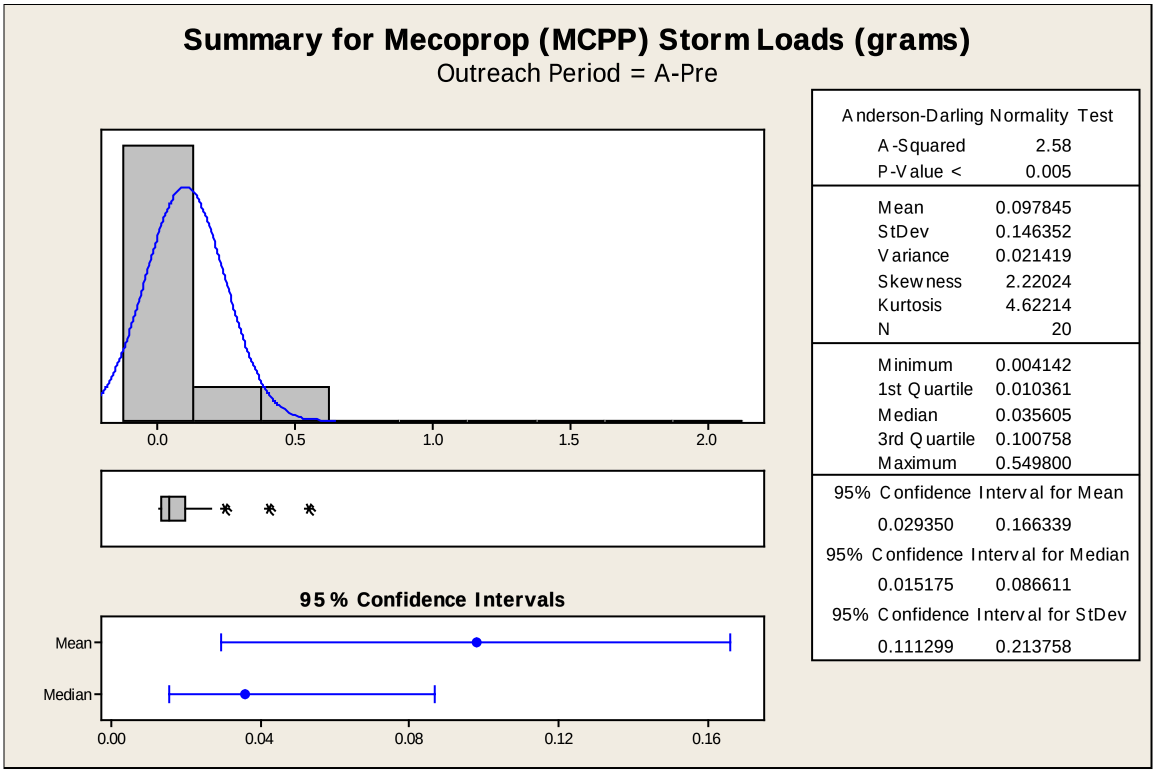
## Appendix 1B  Pre- and Post- Education Storm Loads Summary Statistics

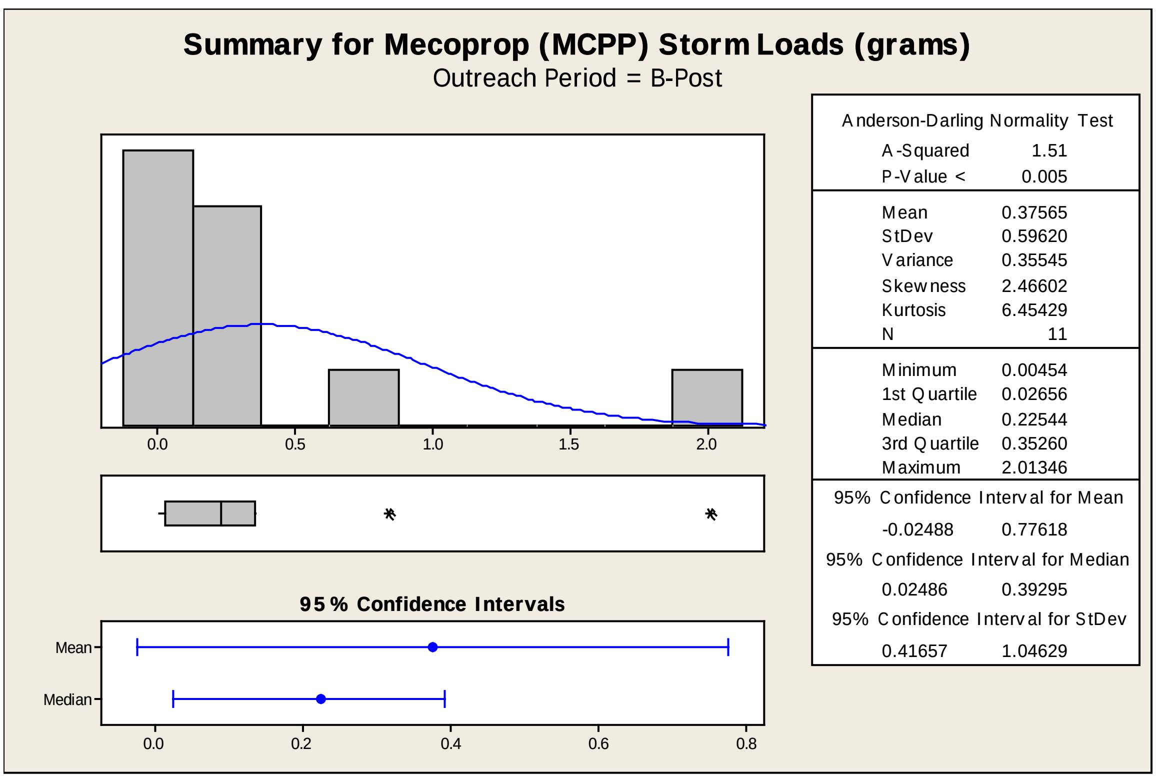

Summary for 2,4-D Storm Loads (grams)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 2.35
P-Value < 0.005
Mean 0.42825
StDev 0.61219
Variance 0.37477
Skewness 1.96099
Kurtosis 3.38353
N 20
Minimum 0.01568
1st Quartile 0.03026
Median 0.19892
3rd Quartile 0.47814
Maximum 2.24738
95% Confidence Interval for Mean
0.14174 0.71476
95% Confidence Interval for Median
0.03250 0.34674
95% Confidence Interval for StDev
0.46556 0.89414
0.0
1.2
2.4
3.6
4.8
95% Confidence Intervals
Mean
Median
0.0
0.2
0.4
0.6
0.8

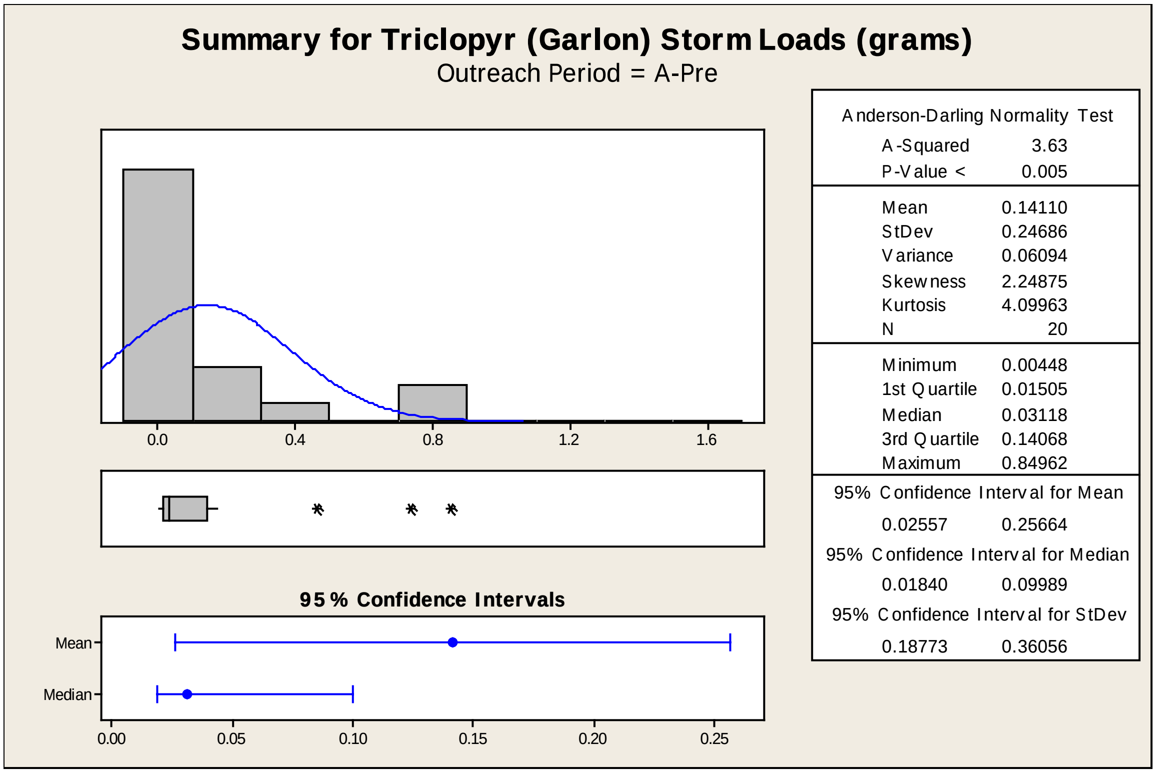

Summary for 2,4-D Storm Loads (grams)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.99
P-Value 0.008
Mean 1.3592
StDev 1.7403
Variance 3.0287
Skewness 1.37078
Kurtosis 0.75953
N 11
Minimum 0.0091
1st Quartile 0.1195
Median 0.5354
3rd Quartile 2.4201
Maximum 5.0336
95% Confidence Interval for Mean
0.1901 2.5284
95% Confidence Interval for Median
0.1113 2.5514
95% Confidence Interval for StDev
1.2160 3.0541
0.0
1.2
2.4
3.6
4.8
95% Confidence Intervals
Mean
Median
0.0
0.5
1.0
1.5
2.0
2.5

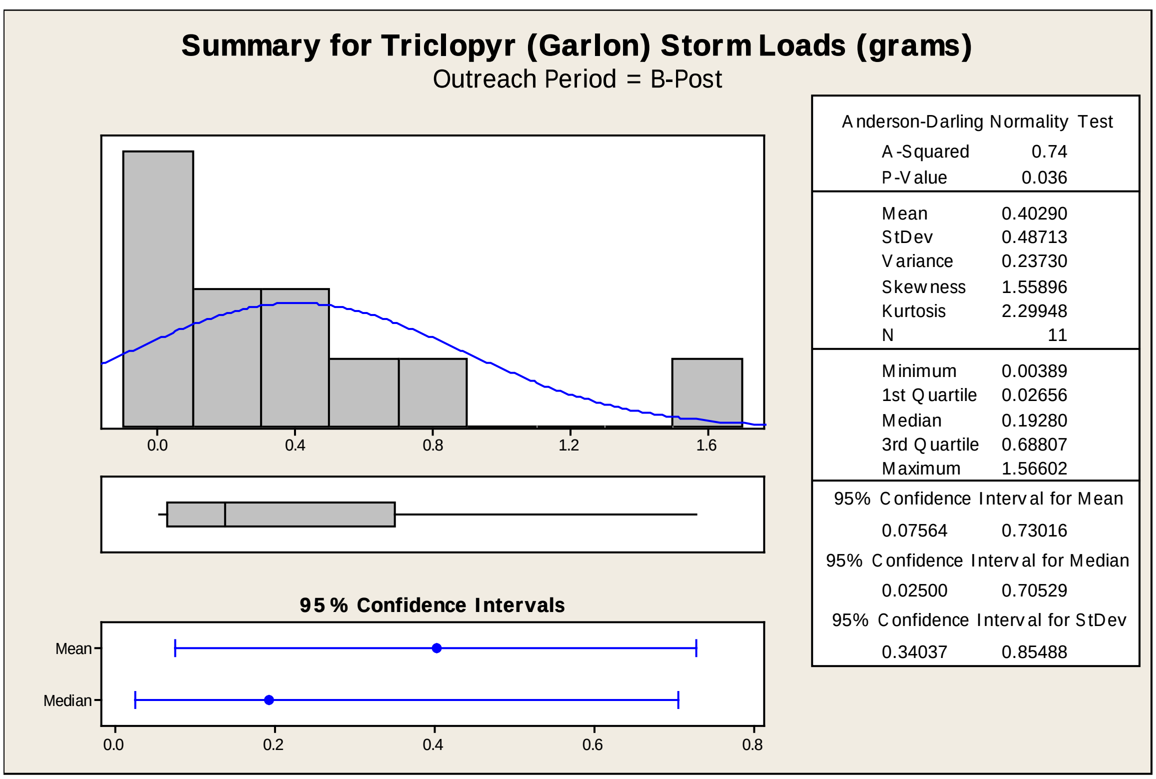

Summary for Dichlobenil Storm Loads (grams)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 1.13
P-Value < 0.005
Mean 0.12978
StDev 0.11869
Variance 0.01409
Skewness 0.62033
Kurtosis -1.25527
N 20
Minimum 0.00207
1st Quartile 0.02816
Median 0.08146
3rd Quartile 0.26319
Maximum 0.34580
95% Confidence Interval for Mean
0.07423 0.18533
95% Confidence Interval for Median
0.03379 0.22432
95% Confidence Interval for StDev
0.09026 0.17336
0.0
0.1
0.2
0.3
0.4
95% Confidence Intervals
Mean
Median
0.05
0.10
0.15
0.20
0.25

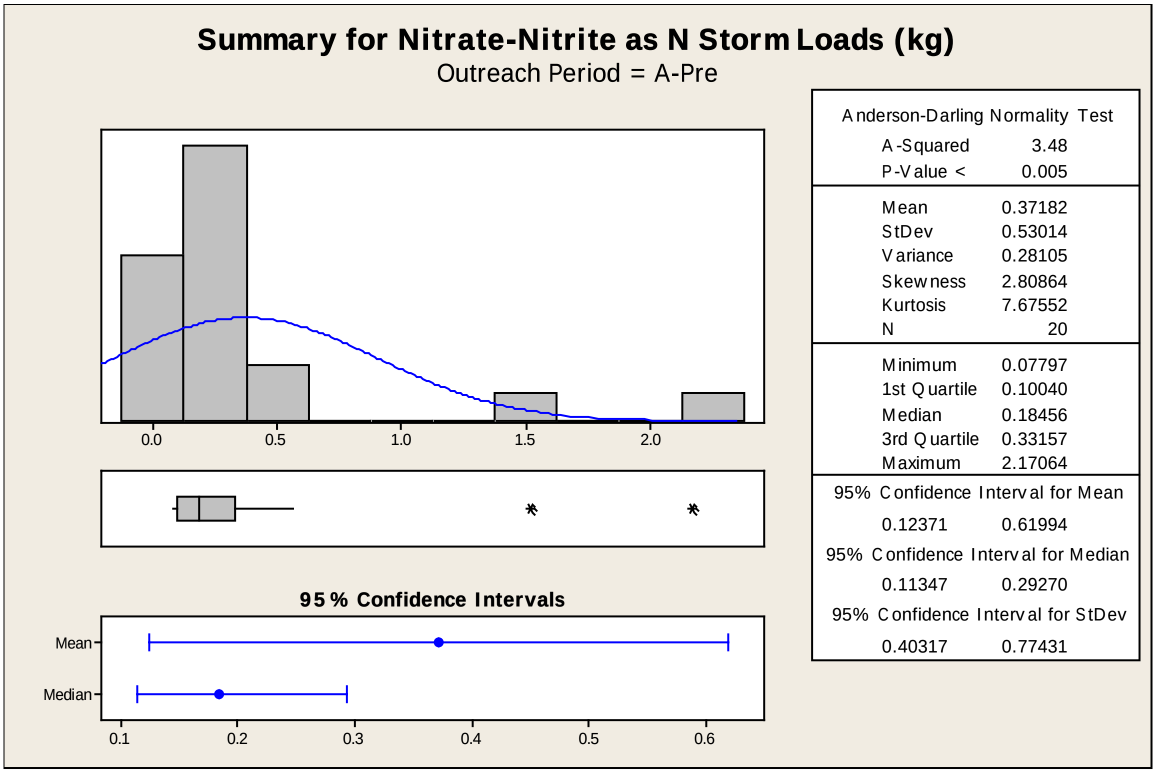

Summary for Dichlobenil Storm Loads (grams)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 1.01
P-Value 0.007
Mean 0.10979
StDev 0.13389
Variance 0.01793
Skewness 1.32124
Kurtosis 0.82462
N 11
Minimum 0.00564
1st Quartile 0.01271
Median 0.03777
3rd Quartile 0.18645
Maximum 0.40269
95% Confidence Interval for Mean
0.01984 0.19974
95% Confidence Interval for Median
0.01252 0.19428
95% Confidence Interval for StDev
0.09355 0.23498
0.0
0.1
0.2
0.3
0.4
95% Confidence Intervals
Mean
Median
0.00
0.05
0.10
0.15
0.20


Summary for Mecoprop (MCPP) Storm Loads (grams)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 2.58
P-Value < 0.005
Mean 0.097845
StDev 0.146352
Variance 0.021419
Skewness 2.22024
Kurtosis 4.62214
N 20
Minimum 0.004142
1st Quartile 0.010361
Median 0.035605
3rd Quartile 0.100758
Maximum 0.549800
95% Confidence Interval for Mean
0.029350 0.166339
95% Confidence Interval for Median
0.015175 0.086611
95% Confidence Interval for StDev
0.111299 0.213758
0.0
0.5
1.0
1.5
2.0
95% Confidence Intervals
Mean
Median
0.00
0.04
0.08
0.12
0.16

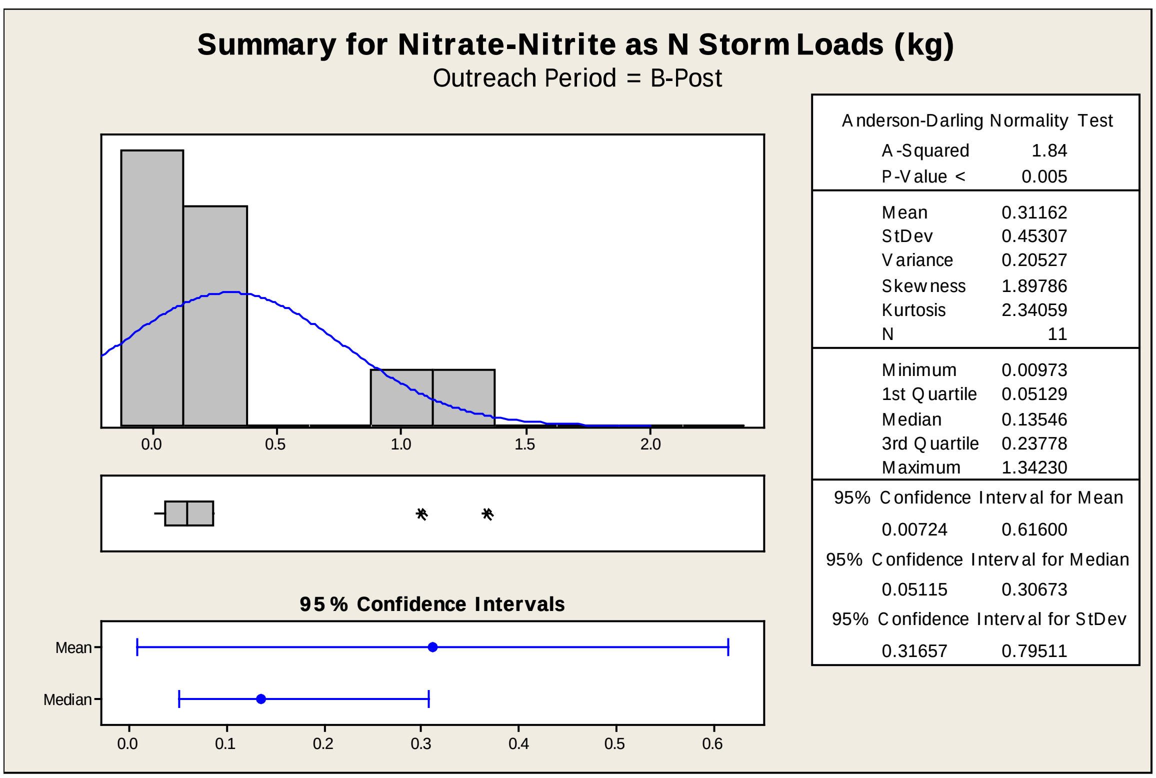

Summary for Mecoprop (MCPP) Storm Loads (grams)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 1.51
P-Value < 0.005
Mean 0.37565
StDev 0.59620
Variance 0.35545
Skewness 2.46602
Kurtosis 6.45429
N 11
Minimum 0.00454
1st Quartile 0.02656
Median 0.22544
3rd Quartile 0.35260
Maximum 2.01346
95% Confidence Interval for Mean
-0.02488 0.77618
95% Confidence Interval for Median
0.02486 0.39295
95% Confidence Interval for StDev
0.41657 1.04629
0.0
0.5
1.0
1.5
2.0
95% Confidence Intervals
Mean
Median
0.0
0.2
0.4
0.6
0.8


Summary for Triclopyr (Garlon) Storm Loads (grams)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 3.63
P-Value < 0.005
Mean 0.14110
StDev 0.24686
Variance 0.06094
Skewness 2.24875
Kurtosis 4.09963
N 20
Minimum 0.00448
1st Quartile 0.01505
Median 0.03118
3rd Quartile 0.14068
Maximum 0.84962
95% Confidence Interval for Mean
0.02557 0.25664
95% Confidence Interval for Median
0.01840 0.09989
95% Confidence Interval for StDev
0.18773 0.36056
0.0
0.4
0.8
1.2
1.6
95% Confidence Intervals
Mean
Median
0.00
0.05
0.10
0.15
0.20
0.25

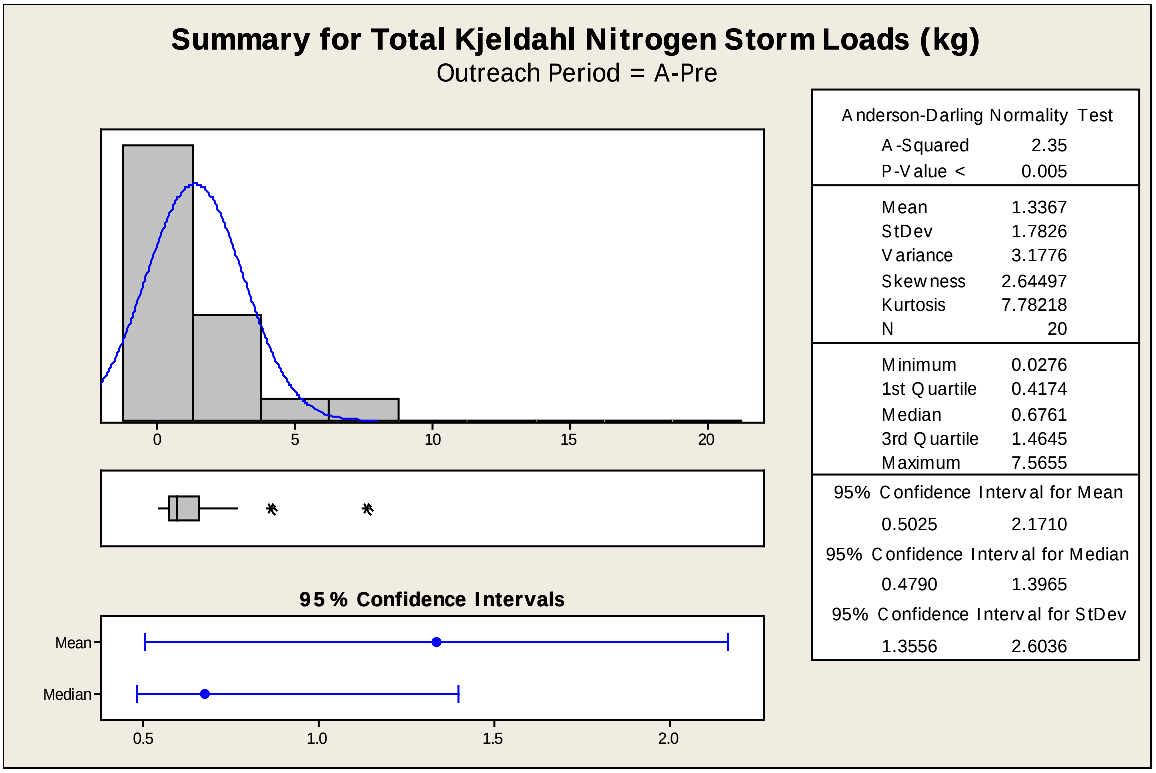

Summary for Triclopyr (Garlon) Storm Loads (grams)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.74
P-Value 0.036
Mean 0.40290
StDev 0.48713
Variance 0.23730
Skewness 1.55896
Kurtosis 2.29948
N 11
Minimum 0.00389
1st Quartile 0.02656
Median 0.19280
3rd Quartile 0.68807
Maximum 1.56602
95% Confidence Interval for Mean
0.07564 0.73016
95% Confidence Interval for Median
0.02500 0.70529
95% Confidence Interval for StDev
0.34037 0.85488
0.0
0.4
0.8
1.2
1.6
95% Confidence Intervals
Mean
Median
0.0
0.2
0.4
0.6
0.8

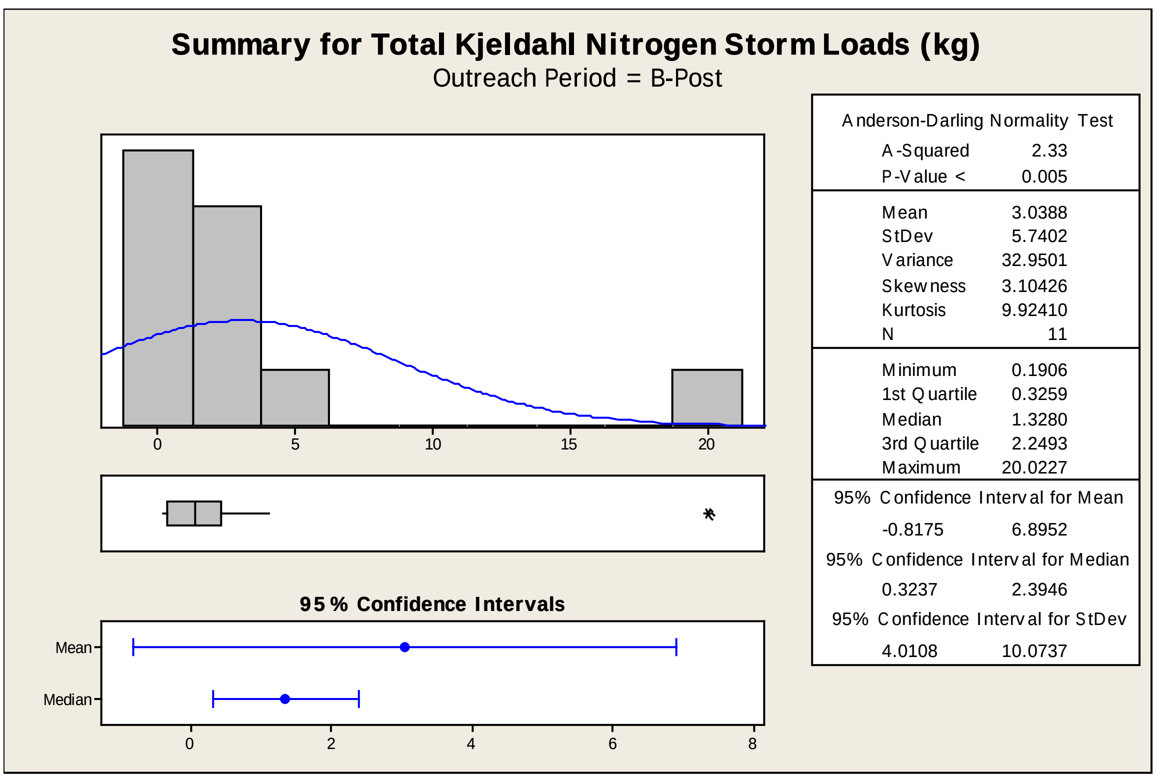


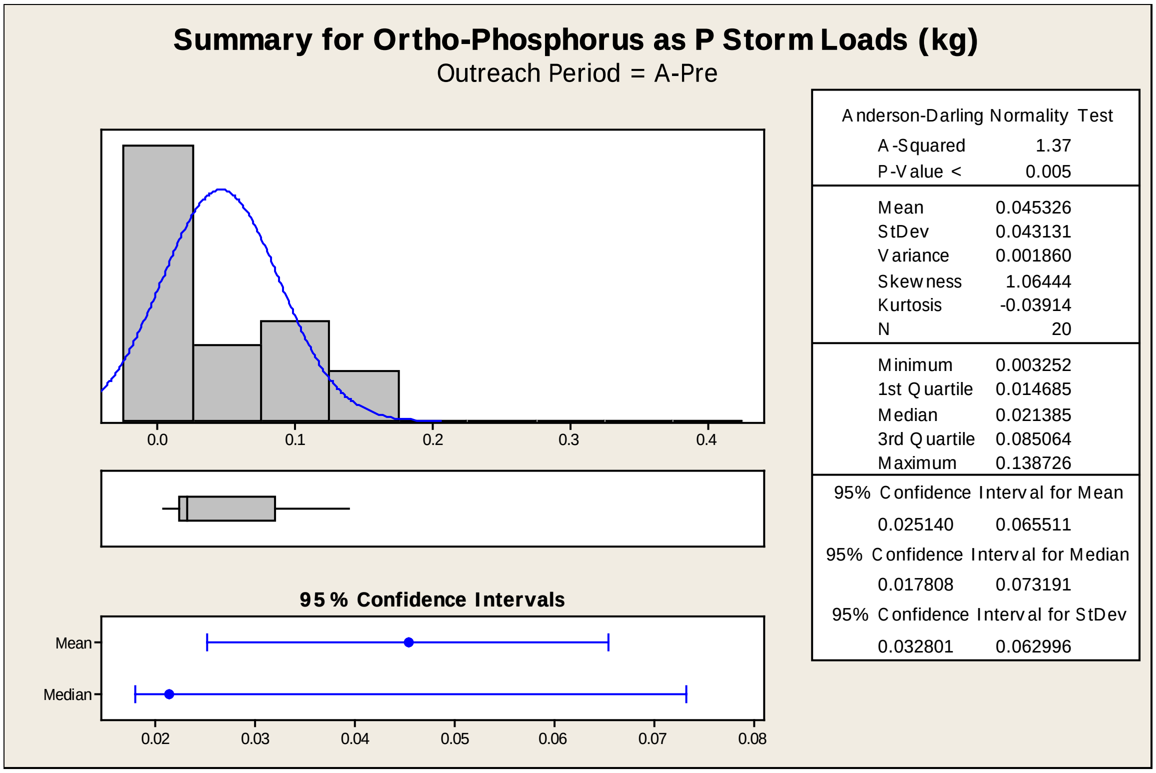
Summary for Nitrate-Nitrite as N Storm Loads (kg)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 3.48
P-Value < 0.005
Mean 0.37182
StDev 0.53014
Variance 0.28105
Skewness 2.80864
Kurtosis 7.67552
N 20
Minimum 0.07797
1st Quartile 0.10040
Median 0.18456
3rd Quartile 0.33157
Maximum 2.17064
95% Confidence Interval for Mean
0.12371 0.61994
95% Confidence Interval for Median
0.11347 0.29270
95% Confidence Interval for StDev
0.40317 0.77431
0.0
0.5
1.0
1.5
2.0
95% Confidence Intervals
Mean
Median
0.1
0.2
0.3
0.4
0.5
0.6

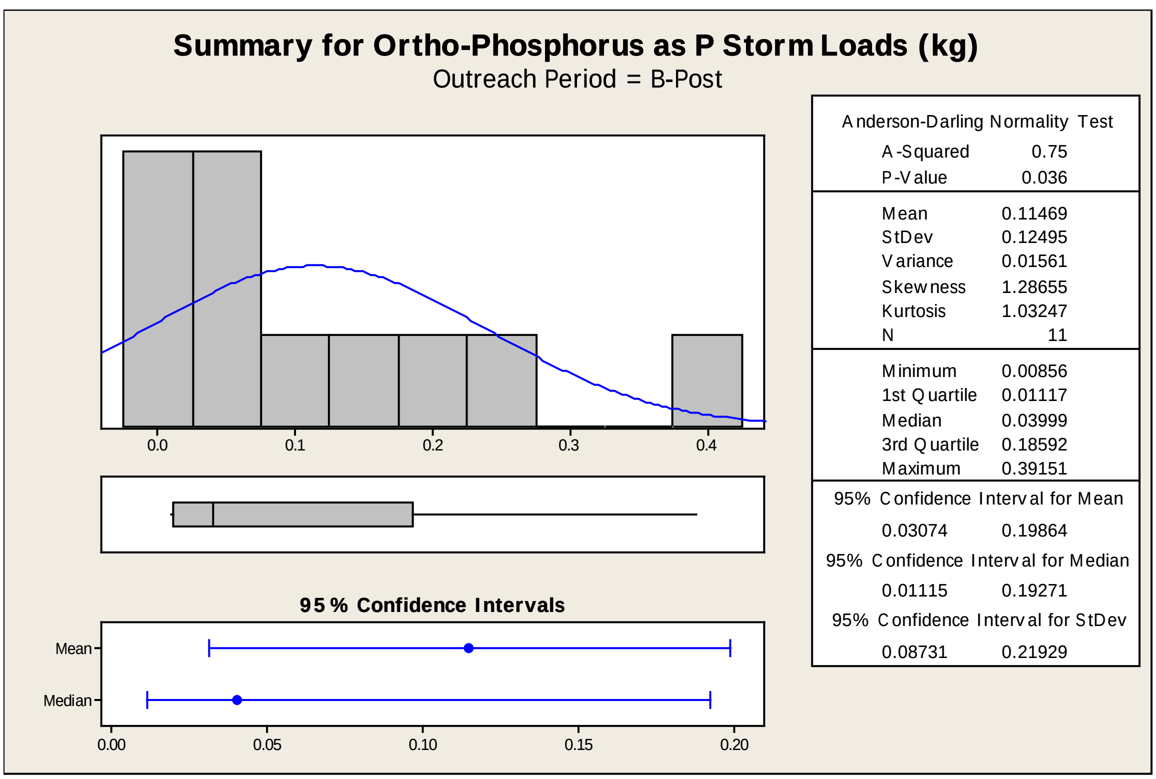



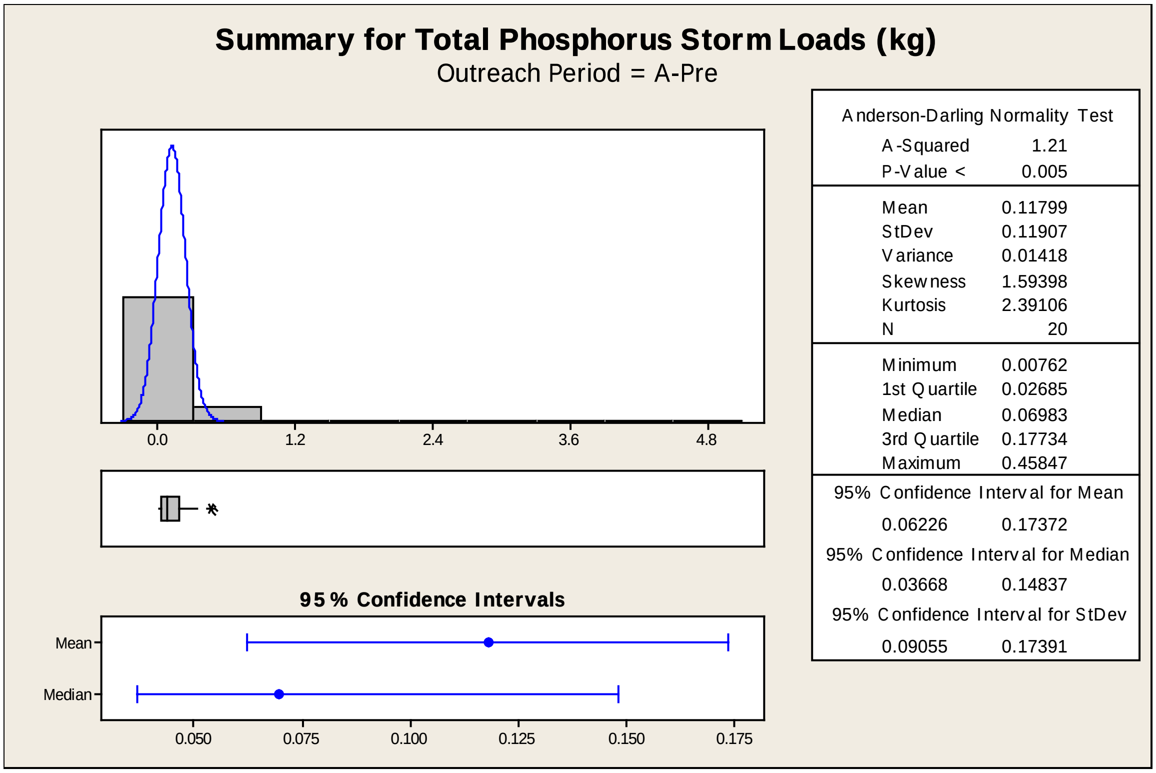
Summary for Nitrate-Nitrite as N Storm Loads (kg)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 1.84
P-Value < 0.005
Mean 0.31162
StDev 0.45307
Variance 0.20527
Skewness 1.89786
Kurtosis 2.34059
N 11
Minimum 0.00973
1st Quartile 0.05129
Median 0.13546
3rd Quartile 0.23778
Maximum 1.34230
95% Confidence Interval for Mean
0.00724 0.61600
95% Confidence Interval for Median
0.05115 0.30673
95% Confidence Interval for StDev
0.31657 0.79511
0.0
0.5
1.0
1.5
2.0
95% Confidence Intervals
Mean
Median
0.0
0.1
0.2
0.3
0.4
0.5
0.6

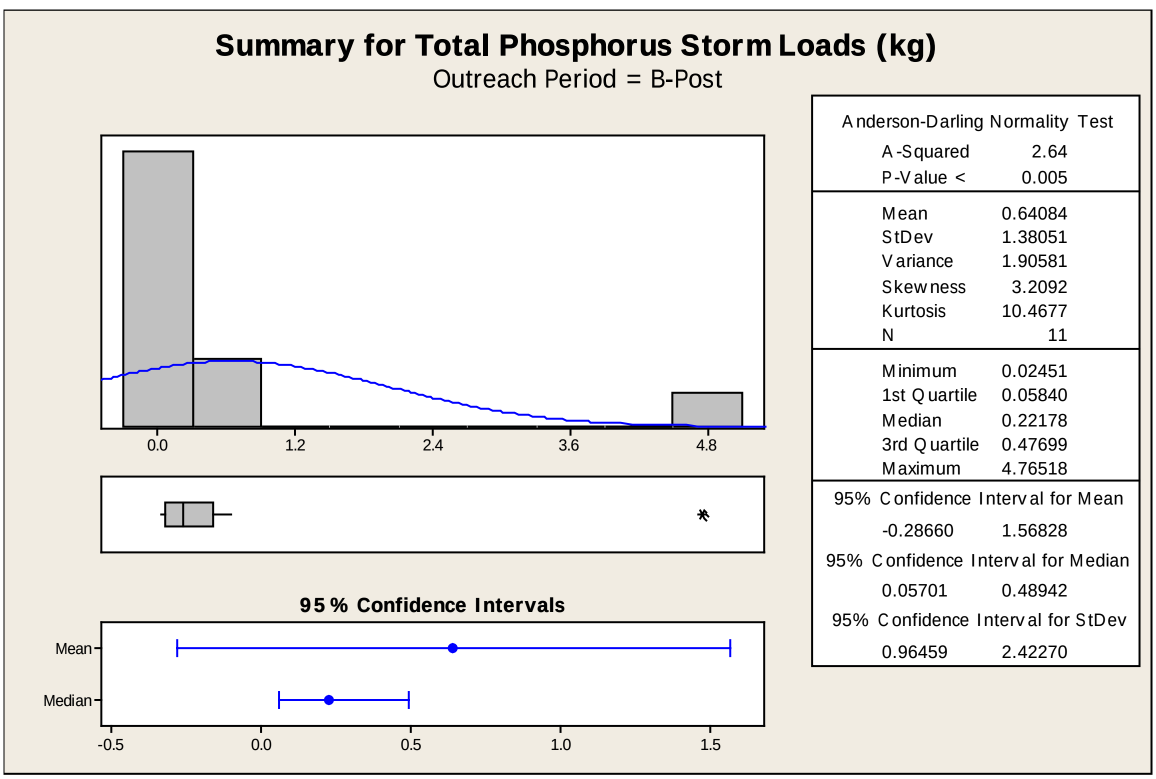

Summary for Total Kjeldahl Nitrogen Storm Loads (kg)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 2.35
P-Value < 0.005
Mean 1.3367
StDev 1.7826
Variance 3.1776
Skewness 2.64497
Kurtosis 7.78218
N 20
Minimum 0.0276
1st Quartile 0.4174
Median 0.6761
3rd Quartile 1.4645
Maximum 7.5655
95% Confidence Interval for Mean
0.5025 2.1710
95% Confidence Interval for Median
0.4790 1.3965
95% Confidence Interval for StDev
1.3556 2.6036
95% Confidence Intervals
Mean
Median
0 5 10 15 20
0.5 1.0 1.5 2.0


Summary for Total Kjeldahl Nitrogen Storm Loads (kg)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 2.33
P-Value < 0.005
Mean 3.0388
StDev 5.7402
Variance 32.9501
Skewness 3.10426
Kurtosis 9.92410
N 11
Minimum 0.1906
1st Quartile 0.3259
Median 1.3280
3rd Quartile 2.2493
Maximum 20.0227
95% Confidence Interval for Mean
-0.8175 6.8952
95% Confidence Interval for Median
0.3237 2.3946
95% Confidence Interval for StDev
4.0108 10.0737
95% Confidence Intervals
Mean
Median
0 5 10 15 20
0 2 4 6 8


Summary for Ortho-Phosphorus as P Storm Loads (kg)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 1.37
P-Value < 0.005
Mean 0.045326
StDev 0.043131
Variance 0.001860
Skewness 1.06444
Kurtosis -0.03914
N 20
Minimum 0.003252
1st Quartile 0.014685
Median 0.021385
3rd Quartile 0.085064
Maximum 0.138726
95% Confidence Interval for Mean
0.025140 0.065511
95% Confidence Interval for Median
0.017808 0.073191
95% Confidence Interval for StDev
0.032801 0.062996
0.0
0.1
0.2
0.3
0.4
95% Confidence Intervals
Mean
Median
0.02
0.03
0.04
0.05
0.06
0.07
0.08


Summary for Ortho-Phosphorus as P Storm Loads (kg)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 0.75
P-Value 0.036
Mean 0.11469
StDev 0.12495
Variance 0.01561
Skewness 1.28655
Kurtosis 1.03247
N 11
Minimum 0.00856
1st Quartile 0.01117
Median 0.03999
3rd Quartile 0.18592
Maximum 0.39151
95% Confidence Interval for Mean
0.03074 0.19864
95% Confidence Interval for Median
0.01115 0.19271
95% Confidence Interval for StDev
0.08731 0.21929
0.0
0.1
0.2
0.3
0.4
95% Confidence Intervals
Mean
Median
0.00
0.05
0.10
0.15
0.20


Summary for Total Phosphorus Storm Loads (kg)
Outreach Period = A-Pre
Anderson-Darling Normality Test
A-Squared 1.21
P-Value < 0.005
Mean 0.11799
StDev 0.11907
Variance 0.01418
Skewness 1.59398
Kurtosis 2.39106
N 20
Minimum 0.00762
1st Quartile 0.02685
Median 0.06983
3rd Quartile 0.17734
Maximum 0.45847
95% Confidence Interval for Mean
0.06226 0.17372
95% Confidence Interval for Median
0.03668 0.14837
95% Confidence Interval for StDev
0.09055 0.17391
0.0
1.2
2.4
3.6
4.8
95% Confidence Intervals
Mean
Median
0.050
0.075
0.100
0.125
0.150
0.175


Summary for Total Phosphorus Storm Loads (kg)
Outreach Period = B-Post
Anderson-Darling Normality Test
A-Squared 2.64
P-Value < 0.005
Mean 0.64084
StDev 1.38051
Variance 1.90581
Skewness 3.2092
Kurtosis 10.4677
N 11
Minimum 0.02451
1st Quartile 0.05840
Median 0.22178
3rd Quartile 0.47699
Maximum 4.76518
95% Confidence Interval for Mean
-0.28660 1.56828
95% Confidence Interval for Median
0.05701 0.48942
95% Confidence Interval for StDev
0.96459 2.42270
0.0
1.2
2.4
3.6
4.8
95% Confidence Intervals
Mean
Median
-0.5
0.0
0.5
1.0
1.5

## Appendix 2A  Mann-Whitney Rank Sum Minitab Statistical Tests of Pre- and Post- Education Differences in Median Concentrations

# Results for: 2,4-D.MTW

### Mann-Whitney Test and CI: Pre 0.5ND Result > Post 0.5ND Result

```
                  N  Median
Pre-ResultVal    20   0.275
Post-Result Val  11   0.450
Point estimate for ETA1-ETA2 is -0.083
95.0 Percent CI for ETA1-ETA2 is (-1.230,0.170)
W = 300.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

### Mann-Whitney Test and CI: Pre 0.5ND Result < Post-0.5ND Result

```
                  N  Median
Pre-ResultVal    20   0.275
Post-Result Val  11   0.450
Point estimate for ETA1-ETA2 is -0.083
95.0 Percent CI for ETA1-ETA2 is (-1.230,0.170)
W = 300.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.2104
The test is significant at 0.2102 (adjusted for ties)
```

# Results for: Dichlobenil.MTW

### Mann-Whitney Test and CI: Pre 0.5ND Result > Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.0755
Post 0.5ND Result  11  0.0360
Point estimate for ETA1-ETA2 is 0.0355
95.0 Percent CI for ETA1-ETA2 is (0.0030,0.1700)
W = 373.5
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0143
The test is significant at 0.0143 (adjusted for ties)
```

### Mann-Whitney Test and CI: Pre 0.5ND Result < Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.0755
Post 0.5ND Result  11  0.0360
Point estimate for ETA1-ETA2 is 0.0355
95.0 Percent CI for ETA1-ETA2 is (0.0030,0.1700)
W = 373.5
Test of ETA1 = ETA2 vs ETA1 < ETA2
Cannot reject since W is > 320.0
```

# Results for: Mecoprop.MTW

### Mann-Whitney Test and CI: Pre 0.5ND Result > Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.0600
Post 0.5ND Result  11  0.1800
Point estimate for ETA1-ETA2 is -0.0400
95.0 Percent CI for ETA1-ETA2 is (-0.1700,0.0400)
W = 291.5
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

### Mann-Whitney Test and CI: Pre 0.5ND Result < Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.0600
Post 0.5ND Result  11  0.1800
Point estimate for ETA1-ETA2 is -0.0400
95.0 Percent CI for ETA1-ETA2 is (-0.1700,0.0400)
W = 291.5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.1238
The test is significant at 0.1231 (adjusted for ties)
```

## Results for: Triclopyr - Garlon.MTW

### Mann-Whitney Test and CI: Pre 0.5ND Result > Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.0500
Post 0.5ND Result  11  0.2700
Point estimate for ETA1-ETA2 is -0.1050
95.0 Percent CI for ETA1-ETA2 is (-0.3000,0.0151)
W = 291.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

### Mann-Whitney Test and CI: Pre 0.5ND Result < Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.0500
Post 0.5ND Result  11  0.2700
Point estimate for ETA1-ETA2 is -0.1050
95.0 Percent CI for ETA1-ETA2 is (-0.3000,0.0151)
W = 291.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.1197
The test is significant at 0.1184 (adjusted for ties)
```

## Results for: Nitrate-Nitrite.MTW

### Mann-Whitney Test and CI: Pre 0.5ND Result > Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.3915
Post 0.5ND Result  11  0.1510
Point estimate for ETA1-ETA2 is 0.1925
95.0 Percent CI for ETA1-ETA2 is (0.0170,0.4181)
W = 375.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0122
```

### Mann-Whitney Test and CI: Pre 0.5ND Result < Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.3915
Post 0.5ND Result  11  0.1510
Point estimate for ETA1-ETA2 is 0.1925
95.0 Percent CI for ETA1-ETA2 is (0.0170,0.4181)
W = 375.0
Test of ETA1 = ETA2 vs ETA1 < ETA2
Cannot reject since W is > 320.0
```

## Results for: TKN.MTW

### Mann-Whitney Test and CI: Pre 0.5ND Result > Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20   0.965
Post 0.5ND Result  11   1.200
Point estimate for ETA1-ETA2 is -0.190
95.0 Percent CI for ETA1-ETA2 is (-0.860,0.301)
W = 303.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

### Mann-Whitney Test and CI: Pre 0.5ND Result < Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20   0.965
Post 0.5ND Result  11   1.200
Point estimate for ETA1-ETA2 is -0.190
95.0 Percent CI for ETA1-ETA2 is (-0.860,0.301)
W = 303.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.2479
The test is significant at 0.2478 (adjusted for ties)
```

## Results for: Ortho-P.MTW

### Mann-Whitney Test and CI: Pre 0.5ND Result > Post 0.5ND Result

```
                    N   Median
Pre 0.5ND Result   20  0.03850
Post 0.5ND Result  11  0.05600
Point estimate for ETA1-ETA2 is -0.01550
95.0 Percent CI for ETA1-ETA2 is (-0.05298,0.00400)
W = 276.5
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

### Mann-Whitney Test and CI: Pre 0.5ND Result < Post 0.5ND Result

```
                    N   Median
Pre 0.5ND Result   20  0.03850
Post 0.5ND Result  11  0.05600
Point estimate for ETA1-ETA2 is -0.01550
95.0 Percent CI for ETA1-ETA2 is (-0.05298,0.00400)
W = 276.5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.0379
The test is significant at 0.0378 (adjusted for ties)
```

## Results for: TP.MTW

### Mann-Whitney Test and CI: Pre 0.5ND Result > Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.0890
Post 0.5ND Result  11  0.1850
Point estimate for ETA1-ETA2 is -0.0915
95.0 Percent CI for ETA1-ETA2 is (-0.1930,-0.0300)
W = 258.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

## Mann-Whitney Test and CI: Pre 0.5ND Result < Post 0.5ND Result

```
                    N  Median
Pre 0.5ND Result   20  0.0890
Post 0.5ND Result  11  0.1850
Point estimate for ETA1-ETA2 is -0.0915
95.0 Percent CI for ETA1-ETA2 is (-0.1930,-0.0300)
W = 258.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.0056
The test is significant at 0.0055 (adjusted for ties)
```

## Appendix 2B  Mann-Whitney Rank Sum Minitab Statistical Tests of Pre- and Post- Education Differences in Median Loads

# Results for: 2,4-D Load.MTW

## Mann-Whitney Test and CI: Pre-Ed Load (grams) > Post-Ed Load (grams)

```
                       N  Median
Pre-Ed Load (grams)   20   0.199
Post-Ed Load (grams)  11   0.535
Point estimate for ETA1-ETA2 is -0.210
95.0 Percent CI for ETA1-ETA2 is (-1.269,0.054)
W = 288.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

## Mann-Whitney Test and CI: Pre-Ed Load (grams) < Post-Ed Load (grams)

```
                       N  Median
Pre-Ed Load (grams)   20   0.199
Post-Ed Load (grams)  11   0.535
Point estimate for ETA1-ETA2 is -0.210
95.0 Percent CI for ETA1-ETA2 is (-1.269,0.054)
W = 288.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.0967
```

# Results for: Dichlobenil Load.MTW

## Mann-Whitney Test and CI: Pre-Ed Load (grams) > Post-Ed Load (grams)

```
                       N  Median
Pre-Ed Load (grams)   20  0.0815
Post-Ed Load (grams)  11  0.0378
Point estimate for ETA1-ETA2 is 0.0205
95.0 Percent CI for ETA1-ETA2 is (-0.0452,0.1015)
W = 341.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.1987
```

## Mann-Whitney Test and CI: Pre-Ed Load (grams) < Post-Ed Load (grams)

```
                       N  Median
Pre-Ed Load (grams)   20  0.0815
Post-Ed Load (grams)  11  0.0378
Point estimate for ETA1-ETA2 is 0.0205
95.0 Percent CI for ETA1-ETA2 is (-0.0452,0.1015)
W = 341.0
Test of ETA1 = ETA2 vs ETA1 < ETA2
Cannot reject since W is > 320.0
```

# Results for: Mecoprop Load.MTW

## Mann-Whitney Test and CI: Pre-Ed Load (grams) > Post-Ed Load (grams)

```
                       N  Median
Pre-Ed Load (grams)   20  0.0356
Post-Ed Load (grams)  11  0.2254
Point estimate for ETA1-ETA2 is -0.0613
95.0 Percent CI for ETA1-ETA2 is (-0.2879,0.0111)
W = 283.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

### Mann-Whitney Test and CI: Pre-Ed Load (grams) < Post-Ed Load (grams)

```
                       N  Median
Pre-Ed Load (grams)   20  0.0356
Post-Ed Load (grams)  11  0.2254
Point estimate for ETA1-ETA2 is -0.0613
95.0 Percent CI for ETA1-ETA2 is (-0.2879,0.0111)
W = 283.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.0659
```

## Results for: Triclopyr (Garlon) Load.MTW

### Mann-Whitney Test and CI: Pre-Ed Load (grams) > Post-Ed Load (grams)

```
                       N  Median
Pre-Ed Load (grams)   20  0.0312
Post-Ed Load (grams)  11  0.1928
Point estimate for ETA1-ETA2 is -0.1244
95.0 Percent CI for ETA1-ETA2 is (-0.4641,0.0068)
W = 281.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

### Mann-Whitney Test and CI: Pre-Ed Load (grams) < Post-Ed Load (grams)

```
                       N  Median
Pre-Ed Load (grams)   20  0.0312
Post-Ed Load (grams)  11  0.1928
Point estimate for ETA1-ETA2 is -0.1244
95.0 Percent CI for ETA1-ETA2 is (-0.4641,0.0068)
W = 281.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.0560
```

## Results for: Nitrate-Nitrite Load.MTW

### Mann-Whitney Test and CI: Pre-Ed Load (kg) > Post-Ed Load (kg)

```
                    N  Median
Pre-Ed Load (kg)   20  0.1846
Post-Ed Load (kg)  11  0.1355
Point estimate for ETA1-ETA2 is 0.0554
95.0 Percent CI for ETA1-ETA2 is (-0.0456,0.1784)
W = 355.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0772
```

### Mann-Whitney Test and CI: Pre-Ed Load (kg) < Post-Ed Load (kg)

```
                    N  Median
Pre-Ed Load (kg)   20  0.1846
Post-Ed Load (kg)  11  0.1355
Point estimate for ETA1-ETA2 is 0.0554
95.0 Percent CI for ETA1-ETA2 is (-0.0456,0.1784)
W = 355.0
Test of ETA1 = ETA2 vs ETA1 < ETA2
Cannot reject since W is > 320.0
```

# Results for: Total Kjeldahl Nitrogen Load.MTW

## Mann-Whitney Test and CI: Pre-Ed Load (kg) > Post-Ed Load (kg)

```
                    N  Median
Pre-Ed Load (kg)   20   0.676
Post-Ed Load (kg)  11   1.328
Point estimate for ETA1-ETA2 is -0.293
95.0 Percent CI for ETA1-ETA2 is (-1.204,0.366)
W = 292.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

## Mann-Whitney Test and CI: Pre-Ed Load (kg) < Post-Ed Load (kg)

```
                    N  Median
Pre-Ed Load (kg)   20   0.676
Post-Ed Load (kg)  11   1.328
Point estimate for ETA1-ETA2 is -0.293
95.0 Percent CI for ETA1-ETA2 is (-1.204,0.366)
W = 292.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.1281
```

# Results for: Ortho-Phosphorus Load.MTW

## Mann-Whitney Test and CI: Pre-Ed Load (kg) > Post-Ed Load (kg)

```
                    N  Median
Pre-Ed Load (kg)   20  0.0214
Post-Ed Load (kg)  11  0.0400
Point estimate for ETA1-ETA2 is -0.0253
95.0 Percent CI for ETA1-ETA2 is (-0.1254,0.0082)
W = 284.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

## Mann-Whitney Test and CI: Pre-Ed Load (kg) < Post-Ed Load (kg)

```
                    N  Median
Pre-Ed Load (kg)   20  0.0214
Post-Ed Load (kg)  11  0.0400
Point estimate for ETA1-ETA2 is -0.0253
95.0 Percent CI for ETA1-ETA2 is (-0.1254,0.0082)
W = 284.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.0714
```

# Results for: Total Phosphorus Load.MTW

## Mann-Whitney Test and CI: Pre-Ed Load (kg) > Post-Ed Load (kg)

```
                    N  Median
Pre-Ed Load (kg)   20   0.070
Post-Ed Load (kg)  11   0.222
Point estimate for ETA1-ETA2 is -0.116
95.0 Percent CI for ETA1-ETA2 is (-0.244,-0.000)
W = 273.0
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 320.0
```

## Mann-Whitney Test and CI: Pre-Ed Load (kg) < Post-Ed Load (kg)

```
                    N  Median
Pre-Ed Load (kg)   20   0.070
Post-Ed Load (kg)  11   0.222
Point estimate for ETA1-ETA2 is -0.116
95.0 Percent CI for ETA1-ETA2 is (-0.244,-0.000)
W = 273.0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0.0274
```